MS # P-129

GERMAN EXPERIENCES IN DESERT WARFARE
DURING WORLD WAR II

- Supplement -

by

Fritz Hermann Bayerlein, Generalleutnant a.D.
Dr. Siegismund Kienow

WITH A FOREWORD BY GENERALOBERST A.D. FRANZ HALDER

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Alfred TOPPE
Generalmajor
Date of Birth: 28 June 1904
Place of Birth: Zernin,
Northern Germany

Alfred TOPPE joined the Army in 1923, entering the 14th Cavalry Regiment at Ludwigslust. After training in both Infantry and Cavalry Officer Candidate Schools from 1924-26, he received his commission as second lieutenant in December of the latter year and was assigned to the 1st Cavalry Regiment, being promoted to first lieutenant in 1929. In 1934 he was detached for a two-year term at the Berlin War Academy, where he was promoted captain (Cavalry) in 1935. From 1936-39 TOPPE served as Quartermaster Training Officer of the XI Infantry Corps and then, after participating in General Staff training courses in 1940, was promoted major and assigned to the Paris Headquarters of the Quartermaster General for France as First Assistant to the Chief Supply Officer. In 1942 he was promoted lieutenant colonel and assigned as Chief, Army Supply Department, Army High Command, where he was promoted colonel in 1943.

Following service as Chief of Staff, X Infantry Corps in Northern Russia from early 1944, TOPPE was transferred back to Army High Command as Army Quartermaster General in June of the same year, in which he remained until the war ended, and where he was promoted Generalmajor in October 1944.

Fritz Hermann BAYERLEIN
Generalleutnant
Date of Birth: 14 January 1899
Place of Birth: Wuerzburg

After very brief service in the German Army late in World War I, BAYERLEIN was in civilian employment for two years, returning to the post-war army as an officer candidate in 1921. He was commissioned a year later and served for ten years in various infantry units. In 1933-35 he studied at the War College in Berlin, and thereafter was a General Staff officer and had principally staff duties. He was a staff officer of an armored division in the Polish Campaign and became a lieutenant colonel at that time. During the French Campaign and the first year of combat in Russia, he was on the staff of XIX Panzer Corps, and in 1941-43 Chief of Staff of the German Africa Corps. During this assignment he was promoted to colonel. Late in 1943 he was promoted to Generalmajor and appointed commander of the 3d Panzer Division on the Russian front. A year later he was again promoted to Generalleutnant and given command of the Panzer Lehr Division, a demonstration unit that saw a great deal of active service in France and Western Germany. Early in 1945, he became commander of the LIII Corps. BAYERLEIN was finally captured in the Ruhr Pocket in April 1945.

Siegismund KIENOW, Ph.D.
Date of Birth: 29 June 1907
Place of Birth: Potsdam.

Dr. KIENOW studied chemistry at the technical college in Breslau in 1925-26 and geology at the University of Breslau in 1926, the University of Koenigsberg in 1926-27, the University of Bonn in 1927-30 and the University of Goettingen in 1930-34. From July, 1934 to June, 1942 he was employed as an assistant in the University of Muenster. In July, 1939 he was drafted for military service and remained in the army until the end of the war, finally reaching the rank of second lieutenant of the reserve.

While serving in the army, Dr. KIENOW continued his academic work and lectured at the University of Muenster and at the University of Strassburg. During World War II, he served as chief of the geological detachment assigned to the German military forces in Africa, where he gained considerable experience in desert problems, particularly those connected with water supplies. In addition, he served in assignments in Norway and in France. In April 1943, he was awarded the title of Regierungsbaurat, a high title in the building and engineering profession. On 7 May 1945, he was captured at Kresmanes, Northern Norway.

In addition to his military service and his activities as a lecturer in Universities, Dr. KIENOW has had considerable success as a writer on geological subjects. Quite a number of his studies have been published in scientific journals of high repute.

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FOREWORD

by

Generaloberst a. D. Franz Halder

The scope of German experience in desert warfare is restricted to that gained in the campaign against the British in the eastern parts of Northern Africa. The point at which all information on this type of experience was gathered was Field Marshal Rommel's staff. Following the demise of Field Marshal Rommel, Generalleutnant a. D. Fritz Bayerlein, who has maintained contact with the former members of the staff and has access to all military material found in Field Marshal Rommel's estate, has become an important expounder of detailed experience on the subject. For this reason, he was the person from whom expert replies had to be obtained to the supplementary questions asked.

In order to round out the replies, it was necessary, in some parts, to revert to ideas expressed in the original study of the subject, MS # P-129. In spite of certain weaknesses due to the repetitions thus involved and to the broad treatment of the problems discussed in the present manuscript, I nevertheless regard General Bayerlein's work as the best reply that could have been furnished to the questions asked within the time allowed.

If the treatment of the problems raised cannot be considered exhaustive in some parts, this is due to the limitations imposed by time, space and available means on German experience in Northern Africa. In this respect I refer the reader to the remarks in my foreword to the main study, MS # P-129.

I agree fully with the thoughts expressed by the topic leader, Generalmajor a. D. Alfred Toppe, in his introduction to the present study.

GERMAN EXPERIENCE IN DESERT WARFARE

IN WORLD WAR II

CHAPTER 1

INTRODUCTION

by

Generalmajor a.D. Alfred Toppe

The additional questions asked by the Research and Development Board in connection with MS # P-129 are answered in the present manuscript by Generalleutnant a. D. Fritz Bayerlein, who was chief of staff to Field Marshal Rommel during the campaign in Africa. In replying to the more important questions, those relating to the problem of water supplies in the desert, General Bayerlein has made use of two studies by Regierungsbaurat * Dr. Sigismund Kienow, a geologist of high repute who served with the German Africa Corps as military geologist from 1941 to 1943. These two studies are included in this manuscript as Chapter 3.

In order to stress the importance of the several problems treated and maintain coherence within this present work, it has been necessary to repeat some of the information given in MS # P-129, the original study on German experience in desert warfare.

If it is found that certain subjects are not treated exhaustively in the sense of the questions asked, this is due either to the fact that no adequate experience is available in the field in question or to the

* A title in the engineering profession.

fact that the fighting in Africa took place in areas in which the features of a true desert were not present.

In any theater of operations, success hinges upon the troops being furnished an adequate supply of all means of combat. However, the proper flow of these supplies is influenced decisively by geographical and climatic conditions.

The problem involved in the present study is not so much what influence the supply services at strategic level, that is, the movement of supplies across the Mediterranean Sea, had on the course of operations. The problem to be examined has to do rather with an examination of the methods employed in supplying the troops, whether the flow of supplies had any restrictive effects on operations and, if so, what those effects were, and whether any improvements can be suggested. So far as combat operations are concerned, the replies given by the author are satisfactory.

Assuming that adequate supplies can be moved currently to one or more strategic supply bases, the movement of supplies of combat materiel to the troops is exclusively a matter of organization, the availability of means of transportation and the possibility to carry out transportation. In ground transportation it must be borne in mind that it is far easier to surmount difficulties by a flexible adaptation to existing circumstances than by endeavoring to force nature. Transportation by air makes practically unlimited flexibility possible.

In modern desert warfare it will always be necessary, once the course of a battle takes a favorable turn, to establish advance supply depots in areas not yet reached by the units in combat so that the enemy can be completely defeated in pursuit. These advance bases will have to be established and protected by airborne troops, who might first have to seize the terrain in combat.

The more important items to be moved forward to the troops in action are fuel, food and water, spare parts for armored vehicles.

The place of the responsible supply officer is on the field of battle. There, he will be able, by means of radio communication or liaison planes, to transmit the appropriate orders and instructions without delay. If kept currently informed on the situation, a properly trained supply staff must be able to function smoothly and reliably even if it receives only brief radio instructions.

All available means of transportation on the ground, in the air and on the sea definitely must be controlled by one central agency. A concentration of effort is just as important in the supply service as it is in combat operations.

Transport planes must be constructed for landing in the desert since time, labor and materials usually are not available for the construction of air strips or permanent air fields when advance bases have to be established or supplies moved forward to advancing troops. This is particularly the case during critical situations, when enveloped troops have to be supplied, or when enemy troops have been pocketed.

Until heavier types of planes with a bigger carrying capacity are so constructed that they can land safely under desert conditions it will be necessary to favor lighter types with a lesser carrying capacity. The further development of tracklaying landing gear might do much to improve the situation in this respect. The supply of combat materiel to advance detachments, encircled smaller units or to patrols employed on missions of several days duration by air drop is an important factor.

Whether the development of special types of vehicles for ground transportation is necessary or practicable is a moot point. Usually, specializations in the transportation services harbor dangers; what might be excellent in one theater of operations might be useless in another. If paved or unpaved firm roads are available, wheeled vehicles will be given preference, for economical reasons if for no other. However, if roads have to be constructed, the very necessity to do so may decide the pace of operations. This fact the commander of a theater of operations can and must accept as a constant. He must fight his battle and endeavor to defeat the enemy when the situation seems most favorable for this purpose. The supply service and everything connected therewith must be adapted to this requirement.

A force which has transportation vehicles capable of moving at the same pace as its combat vehicles can operate independently, as far as supplies are concerned. Here, a high rate of speed is not as important as a steady speed and all-terrain mobility.

It is hardly likely that the assignment of a road construction unit to each division, as suggested by General Bayerlein, will prove practicable. Under desert conditions, a division might move hundreds of kilometers in a direction entirely different from that in which its road construction unit has prepared a road. It would appear more advisable to concentrate all road construction units in a pool and employ them in constructing a really good supply route in the main direction of thrust of the army.

If the operations follow the general direction of a coast, coastal ships with a small draft will play an important role in the transportation services. They are less vulnerable to attack by submarines than large ships and their vulnerability to air attack is relatively negligible. They will prove particularly valuable if they are so constructed and equipped that they can discharge their cargoes on open coasts, thus making the establishment of intermediate bases possible. They can also render excellent service in moving supply bases farther forward.

Water supply columns should not differ visibly from fuel supply columns. The standardization of vehicle types facilitates the functioning of the supply services. It is recommended that water and fuel vehicles should be interspersed in columns to lessen fire hazards.

The author's remark on page 48 that water decontamination tablets were not available in the Wehrmacht is not correct. If these tablets were not used by the combat units during the campaign in Africa their use was apparently unnecessary because the army water decontaminating equipment met all requirements.

CHAPTER 2

REPLIES TO QUESTIONS ON GERMAN EXPERIENCE IN DESERT WARFARE

by

Generalleutnant a. D. Fritz Bayerlein

I. WATER REQUIREMENTS UNDER DESERT CONDITIONS COMPARED TO REQUIREMENTS UNDER NORMAL CONDITIONS IN TEMPERATE ZONES

In the German Africa Corps, experience showed that the quantities of water required by the combat troops under desert conditions were not greater than the minimum quantities stipulated by regulations in temperate zones. This may sound unlikely but it is borne out by experience gained in the 1941-43 period. Under civilian conditions, a person will use far more water than he actually needs and is extremely reluctant to forego his usual habits, for instance, his hygienic practices, particularly if he knows that an abundant supply of water is available. Furthermore, the very sight of water or of other potable liquids induces a feeling of thirst. In contrast, a soldier arriving in a desert immediately adapts himself psychologically to the expected lack of water and with surprising speed accustoms himself to managing with the minimum quantity consistent with health.

Explorers place the minimum requirement at two liters per day and person. However, this applies only to trained athletes with extremely high performances and very moderate requirements and should not be applied to the average man.

In the German army, the minimum daily water ration was four liters, of which amount two liters were used for cooking and two for drinking purposes. No allowance was made for washing. However, the water supply situation was never so critical that the troops had to be restricted to this minimum ration for any length of time. If such a situation arose, the troops perforce had to forego hygienic habits and use only one-quarter or one-half of a liter of water for such purposes. One case in which this necessity arose was during the German retreat from the Tobruk area to the Gulf of Sirte in December 1941.

Regardless of temperatures or seasons, the normal daily consumption of water was six to seven liters. Since this ration was already very low, it was not reduced during the winter months. On the other hand, owing to the shortage of transportation vehicles and motor fuel, it was also not possible to increase the ration in exceptionally hot weather, even if adequate supplies of water were available.

In the British army the normal ration was one gallon (4.54 liters) in regions where water was very scarce and 1.5 gallons per man for troops and other men employed at heavy labor in the vicinity of major water supply points. Details on this subject will be found in Chapter 3, in the copy of a report prepared by the Military Geological Detachment of the German Africa Corps on the water supply organization in the British army.

II. TECHNIQUES EMPLOYED TO FIND WATER

Only geological methods were employed in the search for supplies of water. For this purpose the geological unit assigned to the German Africa Corps based its work on the following considerations:

Two subsoil water levels exist in the eastern part of the Sahara Desert, a deep-water level in the limestone or sandstone strata of the tertiary or chalk formation and a near-surface water level in the loose deposits of wadis *, depressions, loose rock hills and dune areas.

The origin of the deep-water level of Lybia and the so-called western desert of western Egypt is in the regions of high rainfall of the Sudan. The water flows northward through the Nubian sandstone strata and the tertiary chalk and marl formations, as can be seen from the geological profile prepared by the 12th Military Geological Detachment, assigned to the German Africa Corps, in October 1943 (sketch 1, page 9). In valleys and other depressions this water level rises almost to the surface and causes the formation of salt marshes and oases. Under elevated terrain, however, it is very far below the surface and can only be tapped by means of deep well drilling. (Photo 1, page 10). The northern limits of this water level are to be found in the belt of oases along the 29th parallel, part of which region is below sea level. The belt includes the Siwa, Giarabub, Gialo, Augila and Marada oases with their strong artesian springs (photo 2, page 10).

The Cyrenaica, with its high rainfall, is a typical barren rock

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* Dry river beds in Northern Africa.

Anlage 2

Sketch I

Geological Profile

GEOLOGISCHES PROFIL

Matruk-Halfa

Longitudinal Scale 1:2 000 000

(Heights multiplied by 100)

Prepared by 12 Mil Geol.Det.Panzer Army of Africa, October 1942

Loam, Clay and similar

Lehm, Ton u. dergl.

Limestone

Sandstone

Granite, Gneiss etc.

Granite, Gneise u. dergl.

Subsurface Water Level

Sea Level

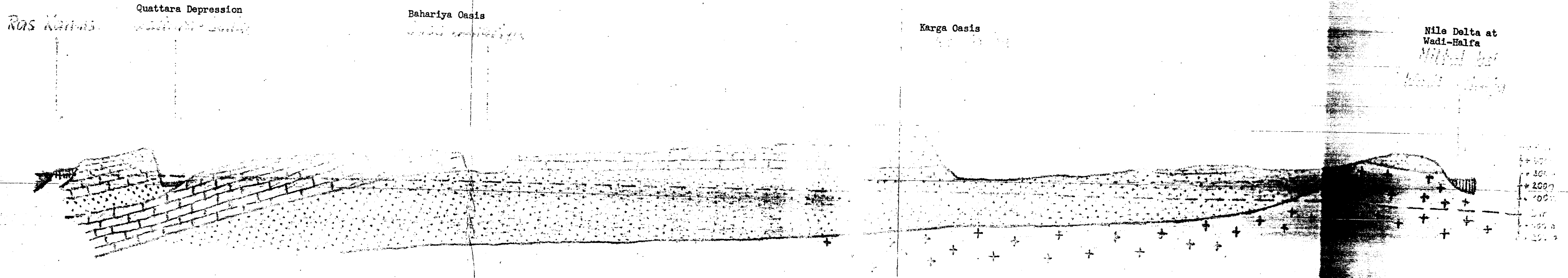
Quarternary

Recent Tertiary

Lower Tertiary and Recent Chalk

Nubian S... (Lower Chalk Formation and older)

Primeval Rock



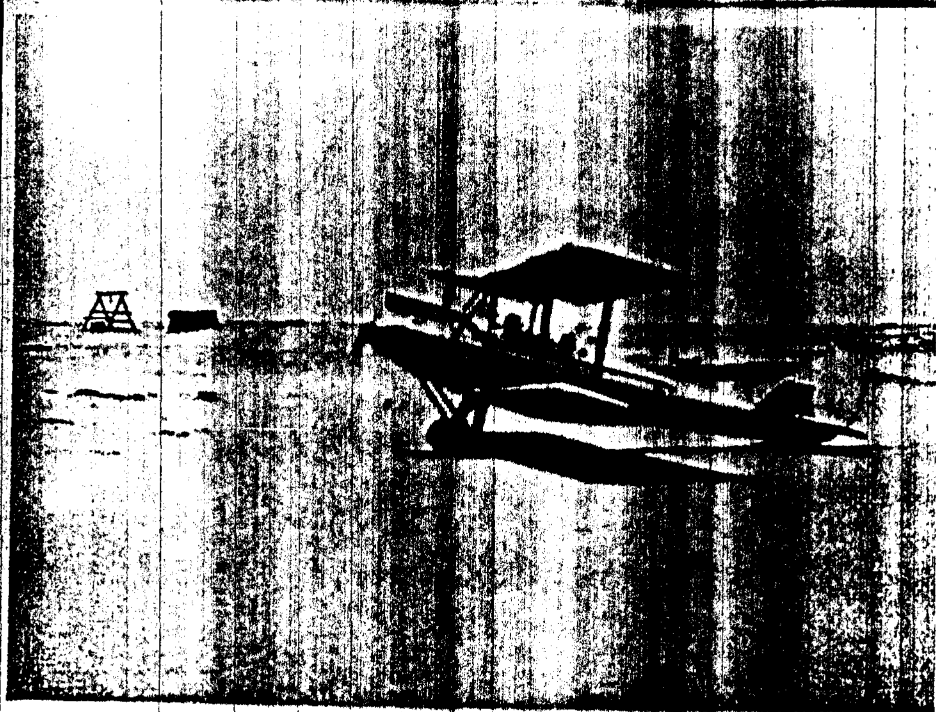


Abb. B V 27 **Bir Misaha,** auch **Mesaha (22° 12' N, 27° 57' O),** liegt an der Piste Djebel Uwenat - Wadi Halfa mitten **auf** einer **Serirfläche,** die zum Landen gut geeignet ist. Als Sichtmarken der **Brunnenstelle** sind ein **kleines Holzhäuschen und ein Holzgerüst** mit Seilwinde zu nennen. Der 67 m tiefe Brunnen (gutes Süßwasser) liegt unter dem Holzgerüst und ist von einem schweren blechbeschlagenen Holzdeckel geschlossen. Ein Seil fehlt am Brunnen und muß mitgeführt werden.

Subsoil Water Obtained by Means of Deep-Well Drilling at Bir Misaha

Artesian Spring in the Marada Oasis

region. The subsurface water is confined to crevices and finds its way to the surface in strong springs (sketch 8, page 70, Water Supply Map, Cyrenaica, 1942).

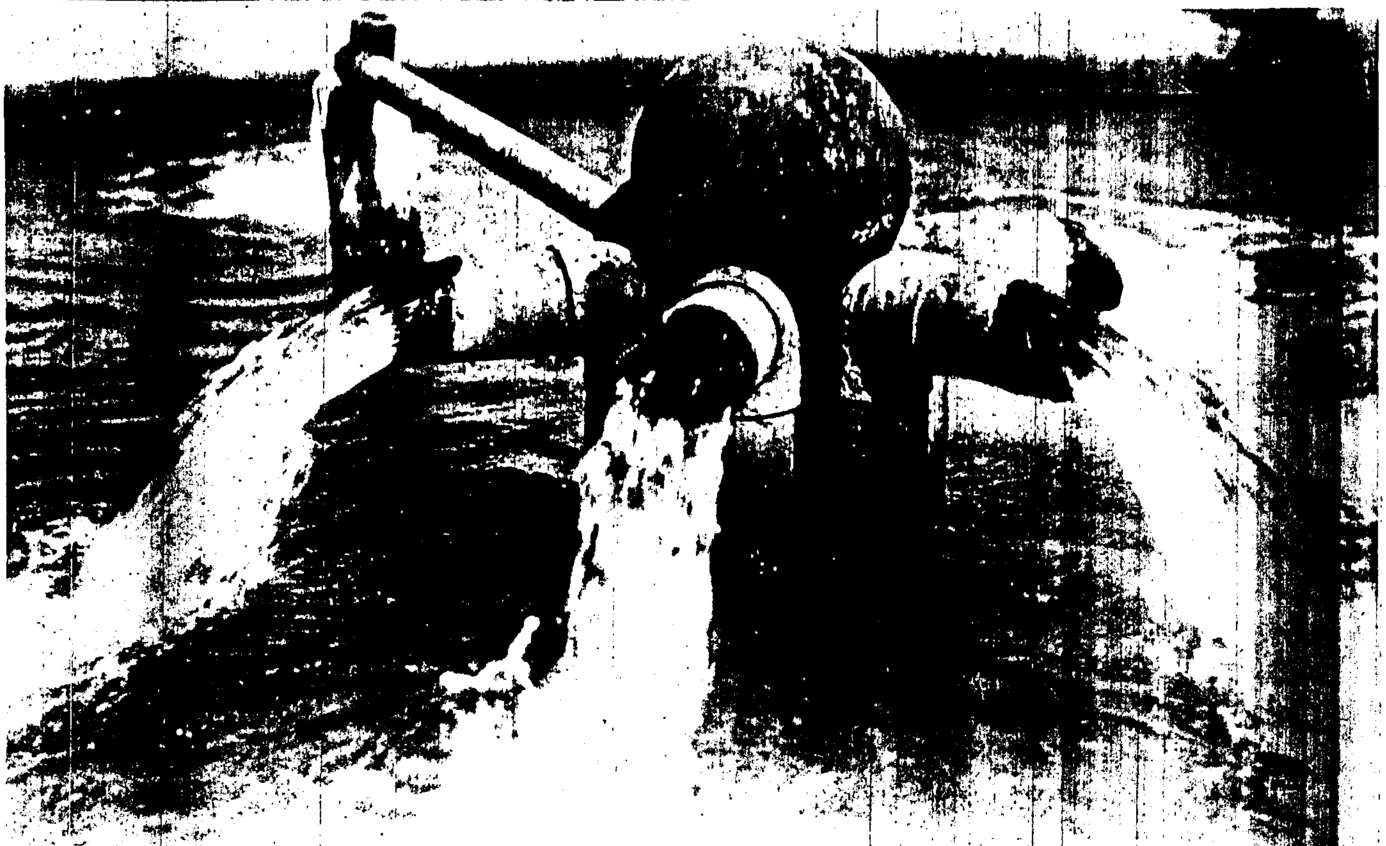
Circumstances are different in Tripoli, where the high Nefusa mountain stops and condenses the moisture carried by the wind from the Mediterranean Sea. The water thus condensed seeps down to lower levels and collects in impervious strata, so that an adequate supply of water can be found in the deep water level of the Djefara, the coastal plain of Tripoli. In certain parts, the water supply is tapped by artesian wells. This water level extends eastward to the region of Misurata, where strong artesian wells were drilled and made the settlement of the region possible (photo 3, page 12).

As far as the availability of water supplies for the Italo-German forces were concerned the situation therefore was as follows:

1. In Tripoli, the deep water level was tapped by so many civilian boreholes that no new drilling was necessary during the brief period of action there (sketch 9, page 71, Water Supply Map, Interior of Tripoli).

2. In Cyrenaica, sufficient strong springs were available to insure an adequate supply of water for large bodies of troops. Deep well drilling, in contrast, is extremely risky in this region, for which reason no new wells were sunk.

3. In the Gulf of Sirte (El Agheila-Marsa El Brega) and in the Marmarica regions as well as in western Egypt north of the Quattara Depression, deep well drilling held out small prospects of success. Therefore no drilling was done in these areas, and work was restricted



Artesischer Brunnen in der neuen landwirtschaftlichen Siedlung „Crispi“ in Libyen

Artesian well in the Crispi Settlement, Misurata

to an exploration and improvement of existing springs along the coast to obtain water for locally assigned troops.

4. If operations had extended to the region of southern Libya and the southern reaches of the western desert, the deep water level there would have become of decisive importance. In this case the available deep well drilling equipment would have been employed. The probable depth at which water could be found would have been determined on the basis of Bell's Map of the Static Subsurface Water Level and local geological surveys (sketch 3, Bell's Map of the Static Subsurface Water Level in the Eastern Libyan Desert, 1927).

The above-surface and near-surface water levels were far more important factors. Immediately after rain commenced, measures should have been taken to catch and conserve the water and to follow it up through all stages of its downward flow in order to store as much of it as possible.

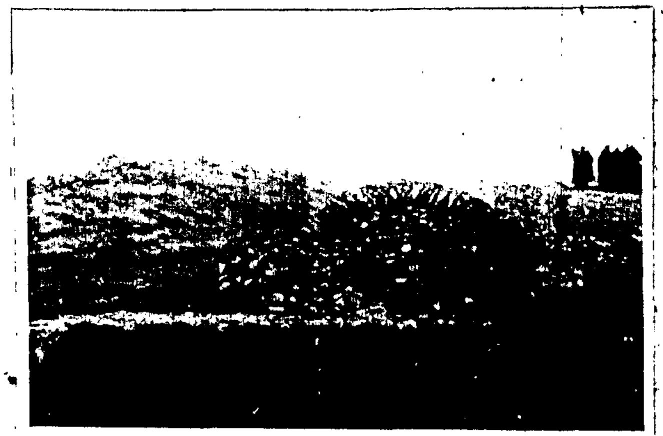
In foggy coastal areas it is possible to obtain water from the air by means of corrugated iron plates, gravel pits and so forth. The quantities are extremely small but often quite useful. House and tent roofs should be constructed to catch rain water.

Troops who are to fight in deserts need appropriate training and instruction in this subject. Every man must realize that every quart of water that he can obtain for himself relieves the burden on the supply services. His resourcefulness must be developed and he must be taught to help himself and not to depend on others. This type of training would have saved us many difficulties on the El Alamein front, but, unfortunately, it was neglected in the German desert army.

Similarly to roofs, flat rock surfaces can be employed to catch water and the water thus obtained can be stored in cisterns. Natural models for the type of installation suggested here can be found in many arid regions; a few examples are the rock bank waterholes of Southwest Africa, the Ugurungas of East Africa, the Gnamma holes of Australia, the rock tanks of Arizona and the Galts of Egypt, all of which are the result of the chemical disintegration of rock, the effects of which are particularly concentrated in small hollows because of the water collecting there. The hollows are enlarged by the action of water during the rain seasons and by the action of the wind during dry seasons, and, if the circumstances are favorable — in the shade, for instance — can contain an appreciable amount of water well into the dry season. They can be enlarged, provided with mud catching devices and protected against animals, and can prove useful in the establishment of strong points in the desert or as water supply points for patrols, small detachments and so forth.

Large cisterns were constructed in ancient times by the Romans (photos 4-7, pages 15-16). However, most of these old cisterns are no longer of any use today, in some cases because their catchment areas have been destroyed in the course of time owing to the natural disintegration of rock. Modern large cistern installations were constructed by the Italians in Libya long before the campaign in northern Africa began (photos 8-10, page 17 and 30-31, pages 48a, 48b).

One important mission of the agency responsible for the supply of water is to ascertain the site of all cisterns existing within the zone



Roman Cisterns in the Zem Zem Wadi

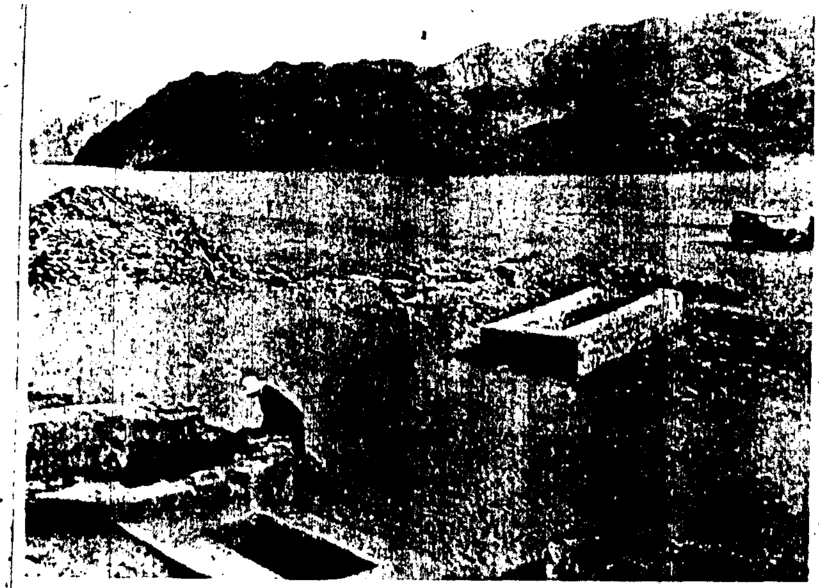


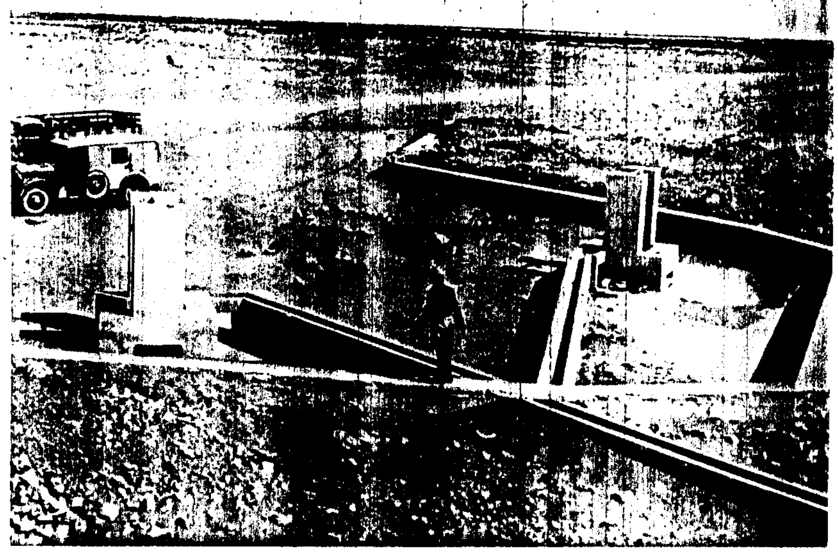
Abb. G 22 **Wadi Hammamat** auf halbem Wege zwischen dem Nil und Kosser. Auf dem ebenen, breiten Wadiboden, über den heute eine befestigte Straße führt, eine Brunnenanlage mit altem Römerbrunnen links.

Roman Cisterns in the Hamamat Wadi

Cistern Ruins at Aim el Gazzla

Bir el Kenayis in the Western Egyptian Desert
Ancient Cistern on the Matruh - Siwa Road

South Cyrenaica
Large Modern Cistern in
Shallow Valley



Bir el Harmat
Cisterns on the
Acroma - Bir Hacheim
trail, showing
catchment walls and
water furrows

Bir Zobada Cistern,
near Gheddahia,
showing Well

of operations and in the communications zone, to examine them in order to determine their usefulness and, if necessary and practicable, to take steps to repair or improve them.

The surface water rapidly finds its way into sand-filled dry river beds called wadis, and from there to pans called deirs or shigfeds and rain lakes called sebkhas, vleys and so forth. Here, it evaporates or becomes brackish. Rain lakes of this type can prove extremely useful in the supply of water for larger bodies of troops for temporary periods.

Some of the water will sink to lower levels through the loose deposits in the lake bottoms. The coarser the deposits are, the greater the amount of water which will sink in this way, but very little of it finds its way to the permanent subterranean water which forms a uniform subsoil water level. The balance of it is retained nearer the surface by capillary action and forms what is called ground moisture, which is gradually drawn upward again into the evaporation areas.

Generally speaking, ground moisture cannot be recovered, although methods are known by which, under certain circumstances, small quantities of water can be recovered which might suffice for patrols or advanced outposts. The indigenous population are masters at recovering water from the ground moisture. They will dig a hole nine to twelve feet deep in the evening and wait a few hours until water has collected in the bottom (photos 11-13, pages 19, 19a). The next caravan to arrive will dig a similar hole a few yards away for the same purpose. These water sites can always be recognized by the large number of holes that have been dug in the bed of a wadi. An inexperienced person is liable to think that they are a

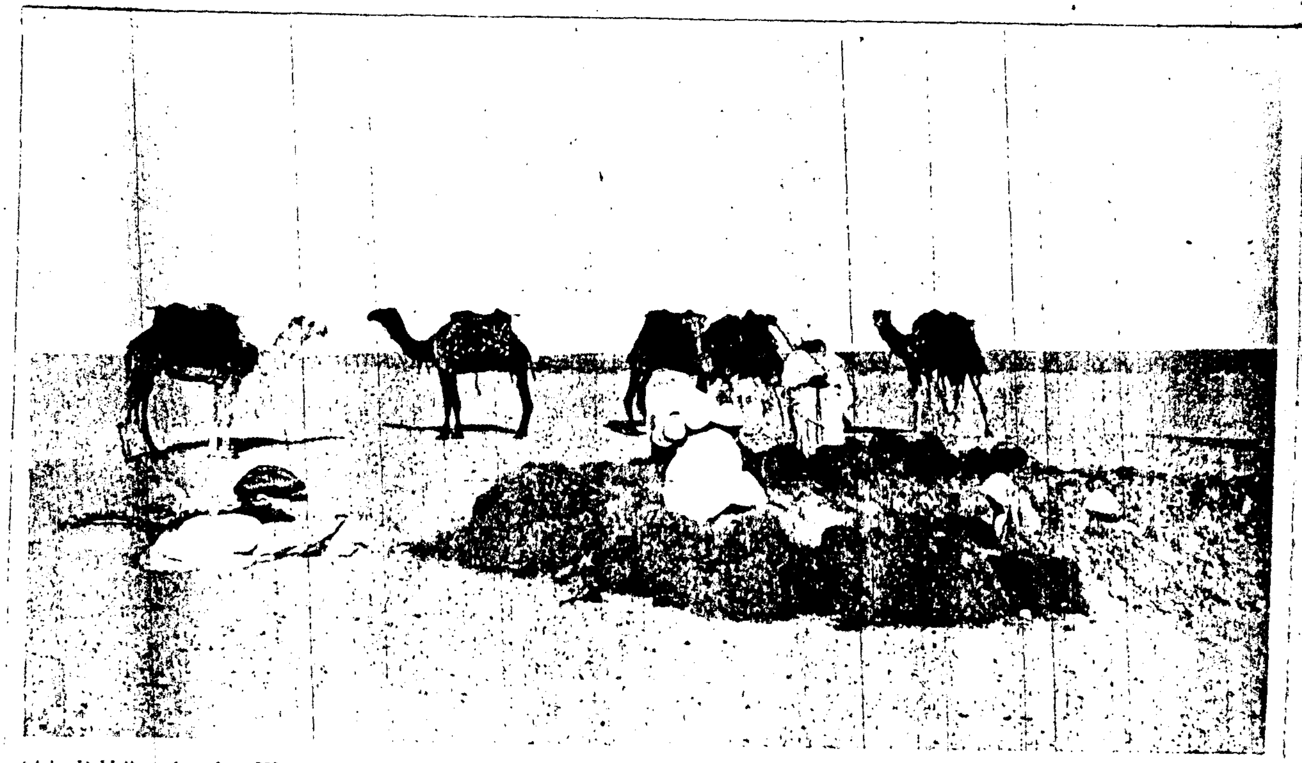


Abb. B II 3 **An der Wasserstelle von Maghara** (30° 14' N, 28° 53' O), am Südende des Salzsees von Maghara, der ungefähr das Ostende der unter dem Meeresspiegel liegenden Kattara-Senke kennzeichnet (vgl. Übersichtskarte). Es ist nur wenig Pflanzenwuchs in der Umgebung vorhanden, das Wasser muß erst aufgegraben werden.

Natives Digging a Well Near Maghara

Abb. B V 29 **Bir Kassaba** 22° 11' N, 29° 55' O, liegt an der Darb el Arbain (Weg der 40 Tage), 45 km N der Piste Bir Misaha—Wadi Halfa. Es befindet sich hier in einer von Steilstufen im W und N umgebenen Senke eine verhältnismäßig dichte Vegetation mit Palmen, die auf Grundwasser schließen lassen. Die zwei Männer im Vordergrund suchen eine geeignete Stelle zum Aufgraben.

Bir Kassaba Water Site, South Libya

Digging Well to Recover Ground Moisture at Bir Kassaba

Abb. B V 30 **Bir Kassaba.** Mit den Händen ist der lose Sand aufgegraben worden und in ½ m Tiefe sammelt sich bereits Süßwasser. Längs der Darb el Arbain finden sich mehrere derartige Brunnenstellen (vgl. Karte 1:500 000).

sign of permanent subsoil water and is disappointed when, upon digging a hole, he finds no water in it. It is necessary for him to know that his labor will only be rewarded if he digs after sunset and that he must wait until the water raised by capillary action finds its way into the hole he has dug.

At times, small mounds form over moist ground, the sand firming down because of the moisture so that it is not blown away by the wind. Areas with a heavy growth of vegetation are also often an indication of plentiful ground moisture (photo 12, page 19a) so that the presence of vegetation can not always be taken as a sign of subsoil water.

True subsoil water is rarely found in the loose deposits of the real desert. It is only where such deposits are thick or where they cover the entire floor of a valley for a long distance and are protected against evaporation that they occasionally carry water in isolated arteries in certain rubble and gravel strata, the course of which does not always follow the general direction of the valley. The point of confluence of two dry river beds is usually a favorable spot for drilling. If the bed of a dry river is impermeable for some distance, a close inspection might reveal sand or gravel filled potholes which might contain water for a long time after rain. If the river bed contains coarse gravel, an effort should be made to find the deepest points of the rock bottom.

The chances of finding water are better in broad, open valleys than in narrow steep gorges, but it would be wrong to dig or drill at spots where the flow of the water has been so slight that it has deposited only a fine sedimentary substance.

Water is often found on the upstream side of rock banks in dry river beds; on the downstream side of such banks there is also a possibility that water may have collected in small quantities in the sand-filled pot-holes formed by the water spilling over the banks. Where a river bed bends sharply, it is always best to concentrate first on the outer bank at the bend, where deep holes may sometimes be found that have been formed by the swirling action of the water.

The closer one gets to the coast, the more subsoil water will be found in dry valleys. Within any sector of the coast extending over several kilometers, water can be found with certainty in the sand or in dune areas, often in sufficient quantities to supply fairly large bodies of troops. However, the quality of the water is variable.

In the vicinity of the coast even the rainwater contains salt in varying degrees, although the chlorine content of 1420 milligrams found by Kaiser in Southwest Africa in 1919 will rarely be found. At Luederitz-bucht, Southwest Africa, Kaiser found 244 milligrams of chlorine per liter of water obtained from the heavy fog and this content is likely to be closer to the average chlorine content of water thus obtained. In the ground, the water becomes more salty, since a great part of the rainwater soaking into the ground subsequently rises again to the surface and evaporates, leaving behind the salt it contained. The result is that the ground and the subsoil water become more and more salty with the passage of time.

Where the subsoil water appears above the surface, evaporation leads to such a strong concentration of salts in the residue of water that salt marshes develop. Relatively close to these salt marshes, water may often be found underground with a far lower salt content since less evaporation takes place. This may surprise the uninitiated but it serves to prove that, in subsoil water, the high salt content of one body of water percolates only slowly to water of a lower salt content. Experience shows, in fact, that the salt content varies both horizontally and vertically.

In the vicinity of the coast, potable water will often be found in thin layers or in small patches floating on top of the salty subsoil water, where it has collected during the last rain without as yet having absorbed salt from the water below it (sketch 2, page 23; Section II, Chapter 3, Operations of the 12th Military Geological Detachment at Sollum). Section II of Chapter 3 contains a report on the finding of a potable water patch of this type in a wadi at Sollum. This report may be taken as a model for the methods to be employed in similar circumstances. Usually, the potable water in such patches is rapidly exhausted and if pumped out too rapidly, salty water will flow into the well. Nevertheless, the supplies obtained thus proved highly valuable and helped to relieve the strain on the supply services.

On the whole, the demands made in respect to the quality of potable water in desert areas should not be as high as in more temperate climates. In the Marmarica region the troops at no time received water with a chlorine content lower than 1 gram per liter, which is usually sufficient to give the water an unpleasant taste. Owing to the large amounts of water used, the salt content of the water obtained from wells increased on the average to 1.2 grams per liter in the late autumn of 1941.

Both humans and animals can adapt themselves to water with a relatively high salt content, and water that cannot be used for drinking purposes often is suitable for baking or for preparing soups and even when it is very brackish it still can be used for making cocoa.

Owing to the sparsity of vegetation and population, water in arid areas rarely contains impurities of an organic nature unless the ground in the vicinity is polluted, against which very strict precautions must be taken. Very severe penalties must be imposed on the pollution of the ground in all areas where wells are situated.

If water tastes and smells dank, the quality can be improved by stirring in some clean sand. When it is allowed to settle to the bottom, the clean sand will have absorbed some of the impurities. A small quantity of alum may be used to accelerate the precipitation of impurities and a few drops of iodine or permanganate of potash can be added to purify the water and improve its quality.

The table on page 25 shows the types of water supply points likely to be found in desert areas, the sites at which they may be found, and further particulars.

Water Supplies in the Deserts of Libya and Egypt

Type	Nature	Sites	Quality	Quantities	How obtained
1	Rainwater	Chiefly in the coastal region	Good	Variable	The rain water is caught and stored in cisterns
2	Dew water	As above	Good	Small	Gravel pits
3	Rain lakes	Desert proper and coastal region	Good	Sometimes large supplies	By pumping
4	Ground moisture	In wadis in the desert proper	Poor to fair	Very small quantities	Holes are dug as required after sunset
5	Near-surface subsoil water level	In wadis, rubble hills, dunes	Variable	Small in the desert proper, ample near the coast	Wells and trenches
6	Deep subsoil water level	Tripolitania and south of the 29th parallel; oases areas	Usually good, frequently warm and with a sulphur content	Ample	Deep wells, frequently artesian
7	Springs	Cyrenaica, Refuza Mountain	Good	Ample	Development of the springs
		Marmarica, western desert	Fair	Very small	Development of the springs

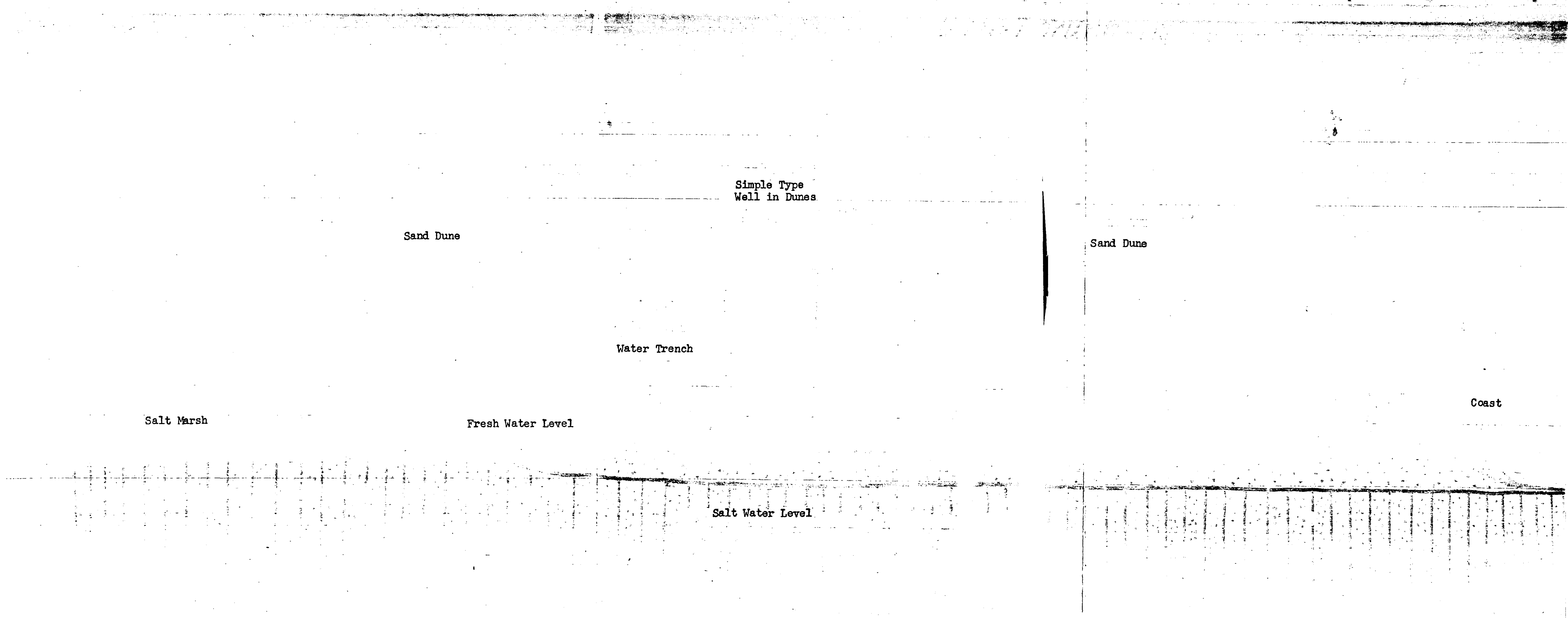
The main source of supply for the German troops in the Sirte region and in the western desert of Egypt was found in the near-surface water level in dunes (sketch 3, page 27; sketch 4, page 28), in the Marmarica region in the near-surface water level in wadis, in the Cyrenaica region in springs (map 2, page 81). Rainwater lakes also played a major role, particularly when the front was at El Alamein. The German forces at no time had to depend on the meager water supplies to be found in the desert proper. It is nevertheless imperatively necessary that the responsible water supply officers inform themselves thoroughly on the water conditions in the desert and instruct their troops currently, so that the troops will be able to help themselves in the case of an emergency. A knowledge of the experience related here has saved the life of many a soldier.

The water present in the deep subsurface water level is recovered by means of deep drilling. For civilian purposes most of the water is pumped by means of windmills (photos 14 and 15, pages 29 and 29a) which have proved extremely satisfactory because of the steady winds which prevail, but which necessitate the above surface storage of an adequate supply.

Springs must be properly developed. At times, the flow of water can be increased by clearing mud and other deposits from the opening of the spring and by removing the sinters. Great care must be exercised to avoid changing the established hydrological conditions in spring areas. Blasting is a hazard in spring areas as it might lead to a complete loss of the water supply.

It was found advisable to direct the flow of water from a number of

Sketch 2


Simple Type
Well in Dunes
Sand Dune
Sand Dune
Water Trench
Coast
Salt Marsh
Fresh Water Level
Salt Water Level

MS # P-129

Sketch 3

Tripoli.
Settlers Cottage
with Windmill

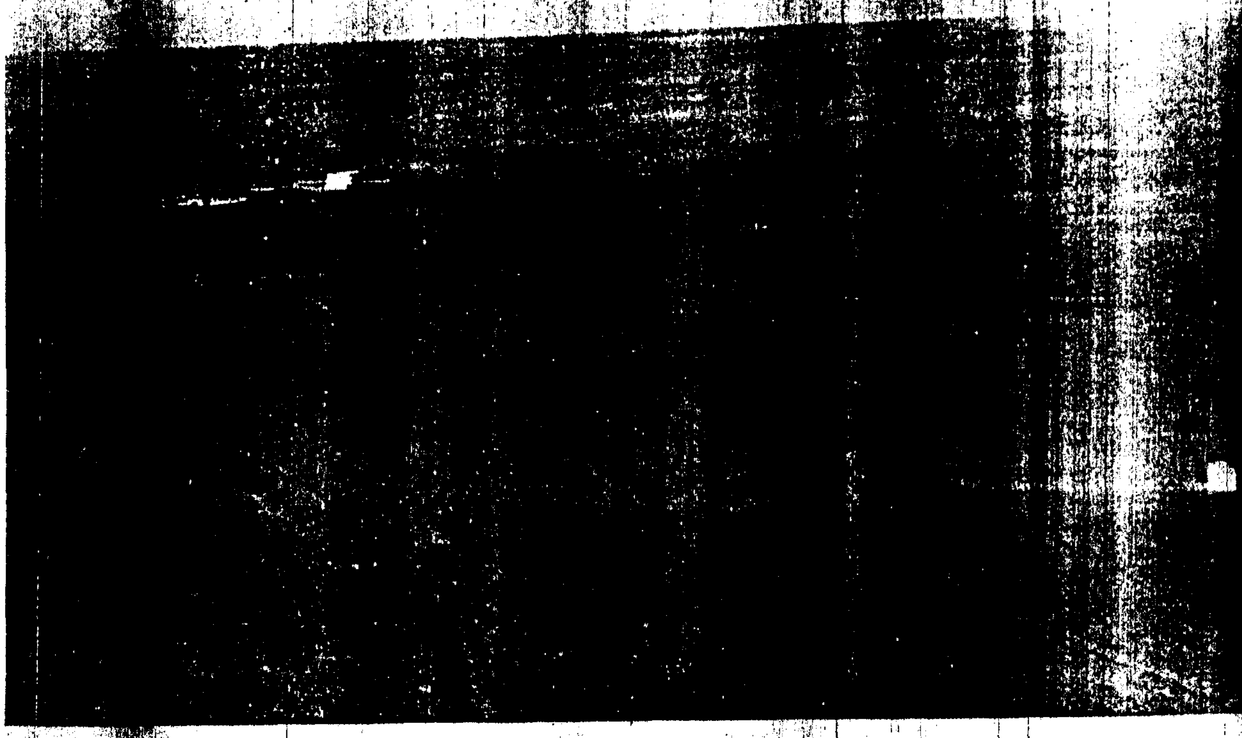


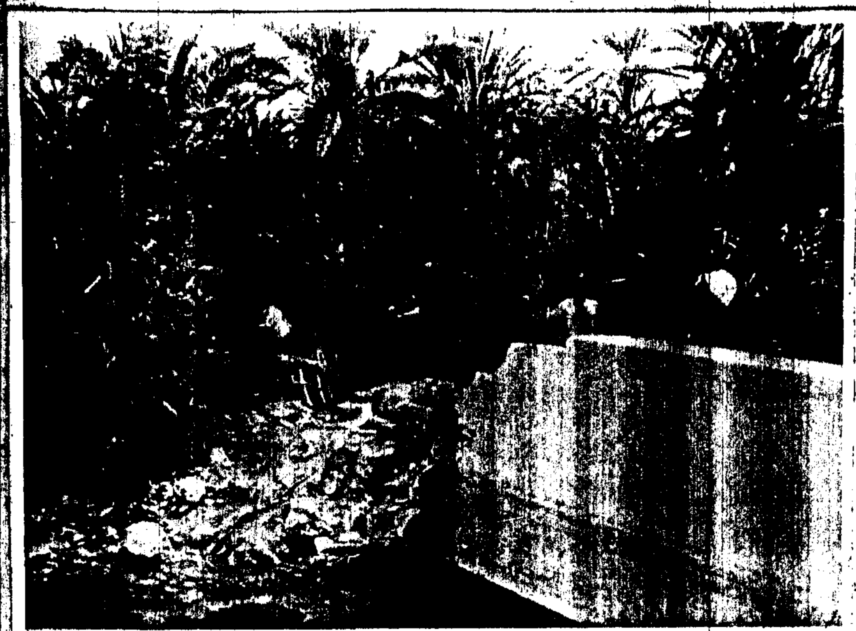
Abb. A IV 10 **Matar,** Brunnen und Pistenkreuzung rund 60 km OSO von Adjedabia, liegt in einem völlig ebenen, einige Kilometer großen Becken, das allseitig 10 bis 30 m ansteigt, der runde weiße Wasserbehälter und das Windrad sind gut zu sehen, letzteres besonders bei Tiefflug. Am Brunnen liegt ein Hilfslandeplatz, an seinem Lande-T und der Eckbezeichnung kenntlich. Der Boden wird von einer festen Sandtenne gebildet, deren Bewachsung äußerst spärlich ist.

Matar, near Agedabia.. Well with Windmill springs into one central pipeline. Filters must be of a type which can be removed and replaced if necessary, since the water frequently contains lime and iron which are precipitated in the presence of air and might decompose the filters. The diameter of the pipes used should be so wide that the pipes will not be filled to capacity even when the springs are at their highest flow. Illustrations of developed springs will be found in photos 16 and 17, page 31.

Water from the near-surface water level is recovered in pit type wells or trenches. The wells are usually one to three meters in diameter. In most cases the wells have to be lined at least part of the way. The best method is by means of concrete rings, but rings made of corrugated iron and angle iron are also useful for this purpose. If metal is used, it is recommended that the sections be joined telescopically. The use of timber is not recommended, but frequently cannot be avoided. The timber requirements for a well 1.5 meters square are given by appropriate experts as twenty-four 16½" x 1" boards.

If there is any danger that salt water from a lower level might enter the well, it is advisable to seal off the bottom with concrete and to provide holes in the lower sections of well lining which will permit the entry of water from the sides. Another expedient which proved useful was to use a movable intake attached to a float, so that water was always pumped only from just below the surface, where the salt content was lowest.

A serious difficulty which is often encountered is the sand which filters into the well from below and from the sides. This not only



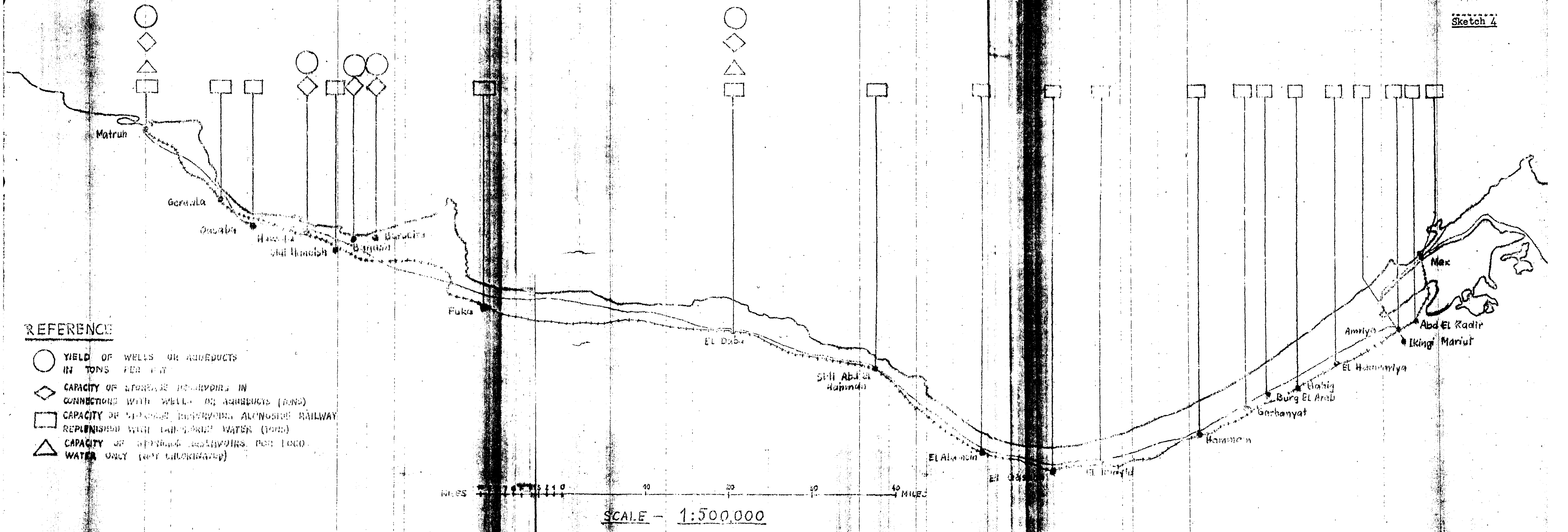
A Built Up Spring at Um er Zem, Cyrenaica

Drawing Water from a Built Up Spring at Ain Mara, Cyrenaica

MS # P-12..
ANLAGE 1

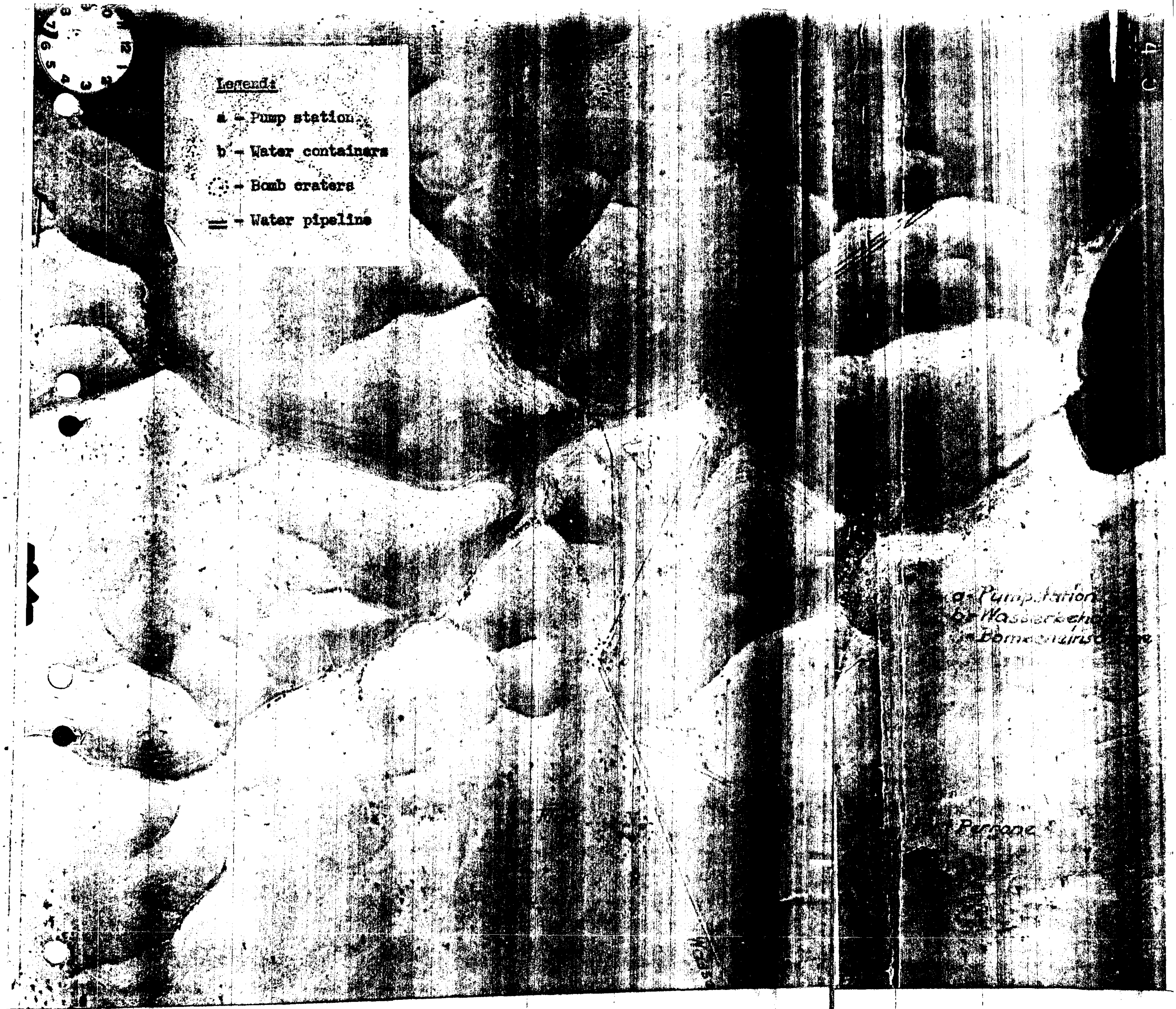
Sketch 4

WATER SUPPLY MAP



WESTERN DESERT-KEY MAP OF DRINKING WATER SITUATION

W/S. PLAN No 29.


Legend:
a - Pump station
b - Water containers
- Bomb craters
- Water pipeline
a- Pumpstation

AN SEA

EASTERN LIBYAN DESERT

STATIC SUBSOIL WATER LEVEL MAP SHOWING LEVEL TO WHICH WATER WILL RISE IF BOREHOLES, BASED ON I. BALL 1927

Legend

Elevations in meters

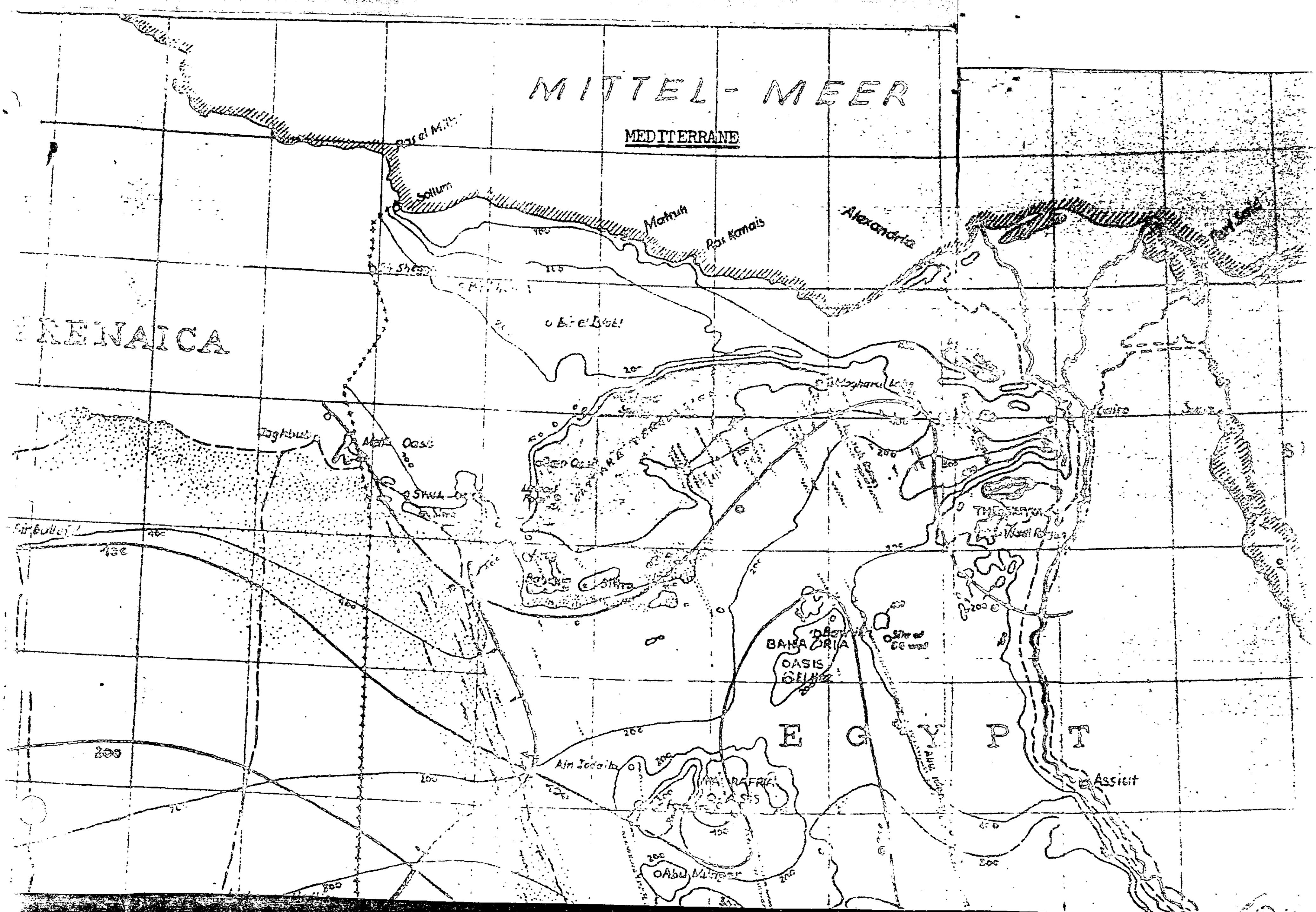
Static sutsoil water level

Areas with a static subsoil water level less than 100 meters below top surface

Caravan routes

Dune areas

Below sea level



MITTEL-MEER
MEDITERRANE
Sollum
Matruh
Alexandria
Port Said
CYRENAICA
Cairo
Suez
BAHARIA
OASIS
Assiut
EGYPT
Ain Dalla
Siwa Oasis

Sketch 10

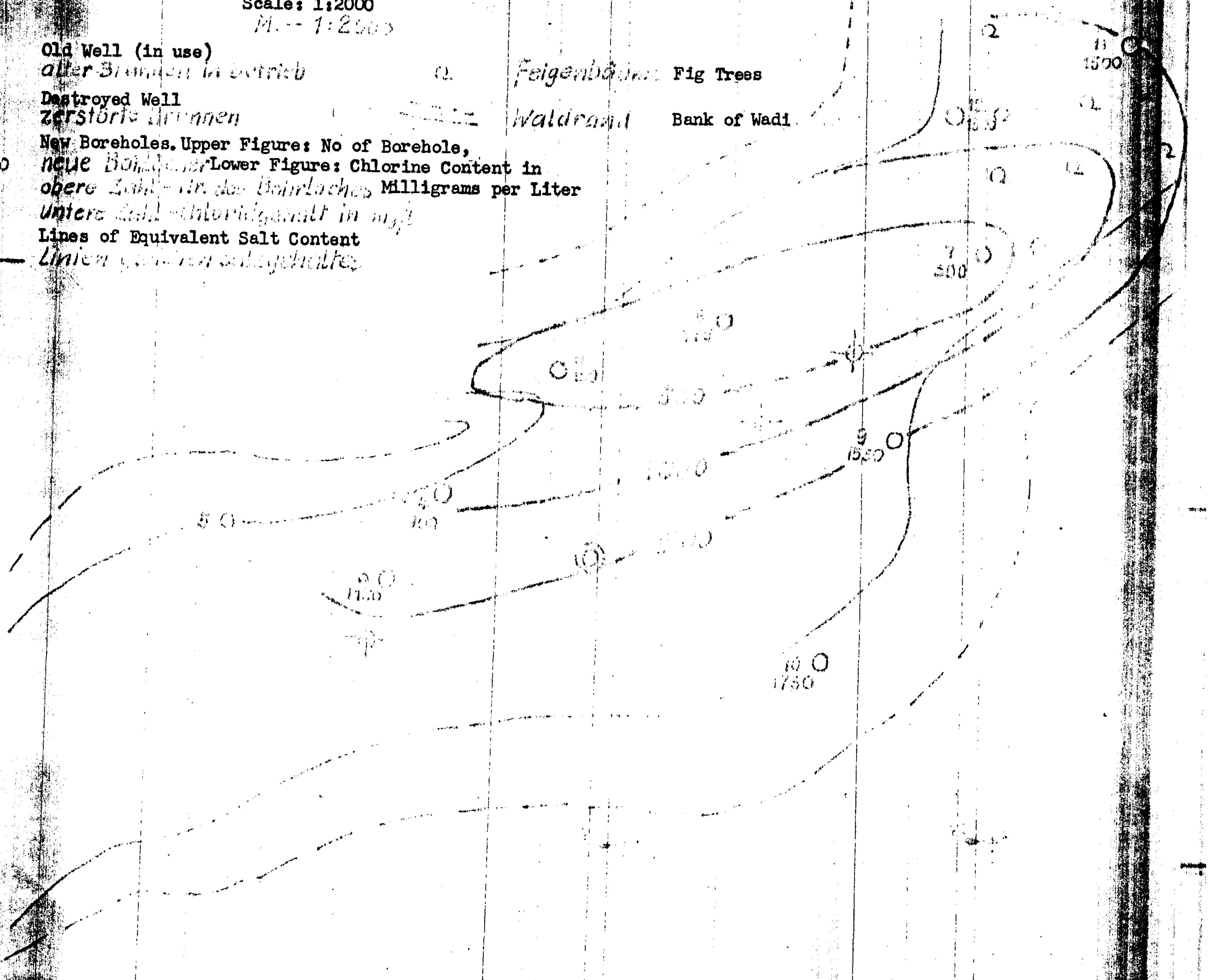
Salt Content of Water in the Hasseyat Wadi

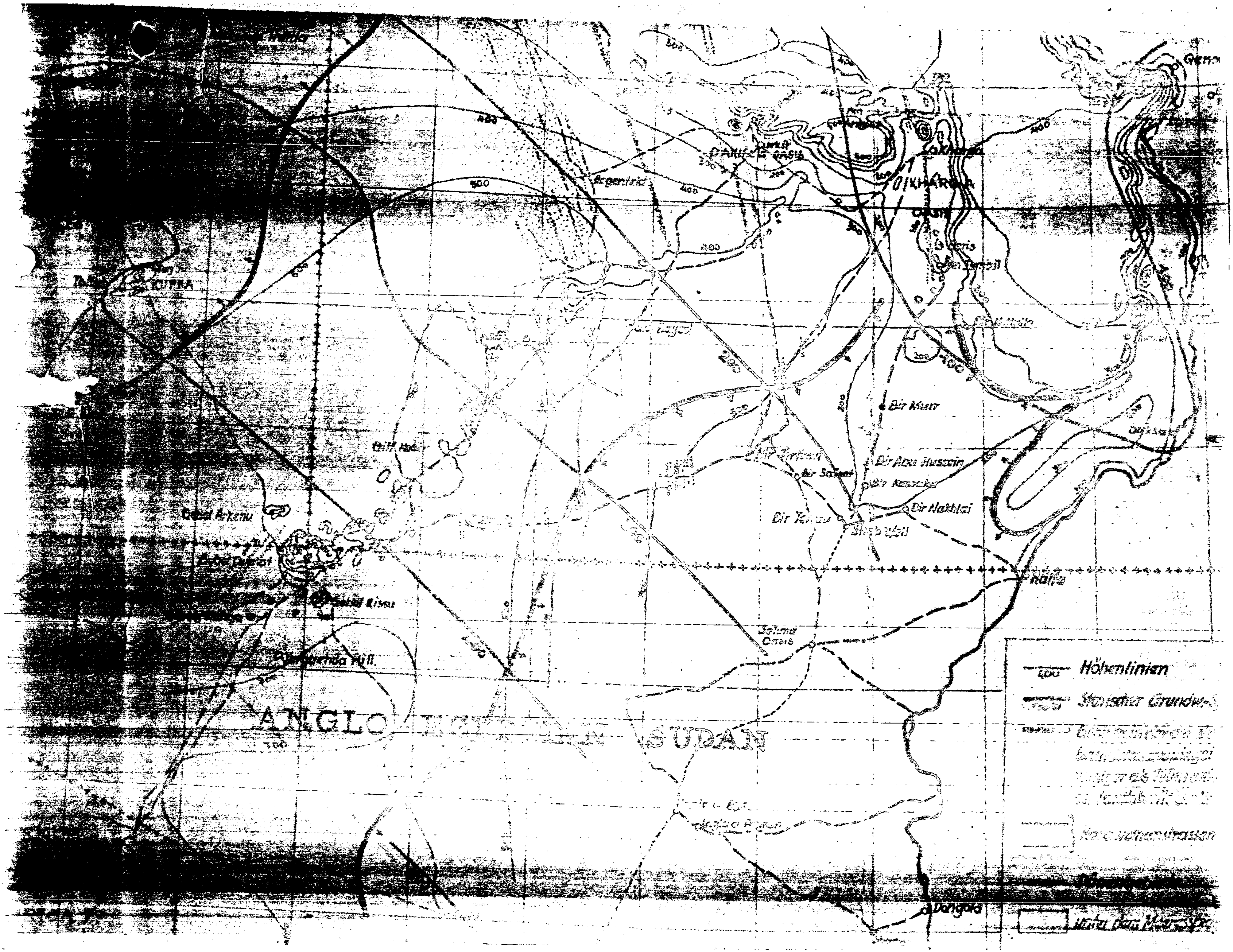
Salzgehalt des Grundwassers im Wadi Hasseyat.

Scale: 1:2000

M. 1:2000

- Old Well (in use) — *alter Brunnen in Betrieb*
- Destroyed Well — *zerstörte Brunnen*
- 6 / 100 — New Boreholes. Upper Figure: No of Borehole, Lower Figure: Chlorine Content in Milligrams per Liter — *neue Bohrlöcher, obere Zahl: Nr. des Bohrloches, untere Zahl: Chloridgehalt in mg/l*
- ~500~ — Lines of Equivalent Salt Content — *Linien gleichen Salzgehaltes*
- *Feigenbäume* — Fig Trees
- *Waldrand* — Bank of Wadi





KUFRA
DAKHLA OASIS
KHARGA
OASIS
Bir Murr
Bir Abu Hussein
Bir Nakhlai
Bir Tarfawi
Selima
Oasis
ANGLO
SUDAN
Dongola
Höhenlinien

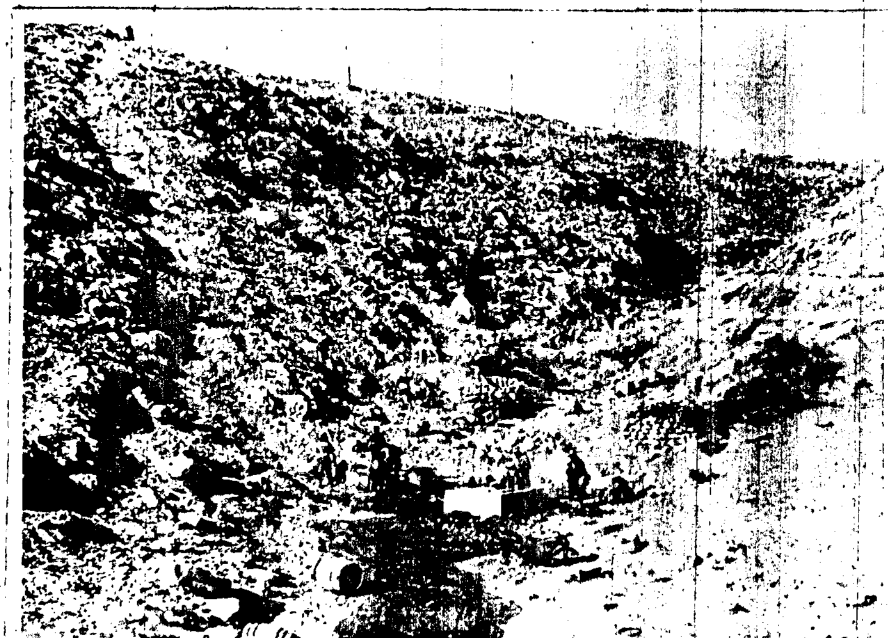

rmy Engineer Commander
2th Military Geological Detachment
Roughly 1000 cubicmeters
daily. Quality good
merous shrings, some strong
Several hit-type wel
Numerous Cisterns
nur Zisternen
only cisterns

fills up the well but, because of the sand settling down around the sides of the well, might make it difficult to keep the lining straight. In such cases it is helpful to place coarse gravel around the well; this gravel will settle with the sinking sand and finally will prevent any further sand from entering the well. It also proved helpful to place gravel and boulders, the finer gravel at the lower levels, in the bottom of the well before pumping commenced. In the case of wells with a very large diameter, the danger of sand filtering in is somewhat reduced.

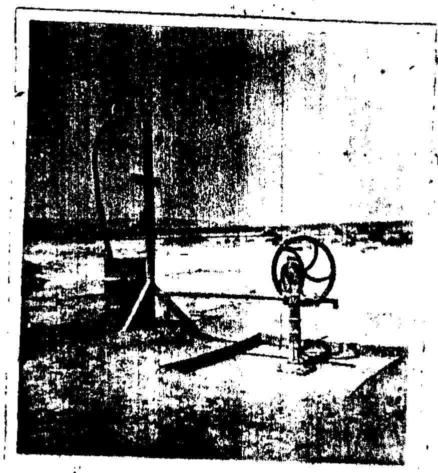
If wells are sunk in the beds of dry rivers, everything possible must be done to prevent the influx of above-surface water when the river is in flow. The sides of the well must be walled with concrete. The walls must either be raised well above the level of the river bed or must be flush with the bed and so built that they can be securely covered. The best place for the pumps is on the river bank and the pipes must be buried so that pumping can continue even if the river is in full flow.

The well system at Tobruk is the biggest to be found in a dry river bed in the Marmarica region. It was constructed by the Italians during peace and has two pumping stations which force the water into elevated reservoirs from which it flows into the water mains of the town (photo 18, page 33). During the siege of Tobruk, all attempts of the German air force to destroy these installations failed.

Photo 19, page 34, illustrates a well dug in a wadi near Bardia during the war. Photo 20, page 35, shows a well dug by the Italians at Ain el Gazala, also during the war, and the very serviceable hand pump



[illegible]. Water Site in the [illegible] Wadi



Italian Well at Ain el Gazala

Sollum. Well with Abessinier * Field Type Pump

* Trade name

which was used there. This installation is exemplary. Photo 21, page 35, shows work on a well with a German Abessinier * field type pump at Sollum.

In many cases it is impossible to obtain sufficient water, no matter how big the well is. In such cases, the catchment area is increased by means of trenches, which proved particularly useful in dune areas and in broad wadis. Photos 22-24, pages 37-39, show a water trench system under construction at the Martuba oasis near Derna. In this case, the sides of the trenches were lined with unmortared rocks. When all work is completed the trenches are covered and sand shoveled over the top. The trenches are dug at right angles to the flow of the subsoil water with a fall in the direction of a central collecting well, where the pump is situated. Photo 25, page 40, shows a central well of this type, complete with pipes, in the dunes at Ain el Gazala. The water trench system was used primarily in areas where water was thinly spread over a wide area, a condition which will be found in most water supply points in arid regions. For this reason, the water trench system is the system usually employed in all large scale water recovery installations in the desert (sketch 3, page 37).

III. ORGANIZATION OF WATER SUPPLY UNITS IN NORTH AFRICA

In the first year of the African campaign, from 1941 to the spring of 1942, water supply units were assigned to the headquarters of the German Africa Corps and to each of the two armored divisions. The corps headquarters water supply battalion consisted of:

1 heavy water supply construction company, 200 strong, with drilling

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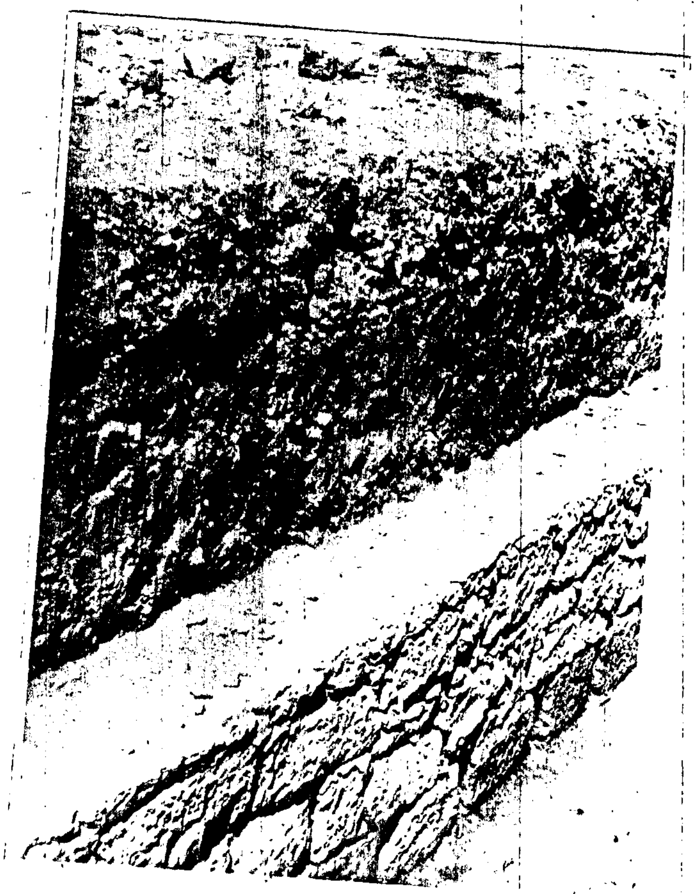
* A trade name

Water Trench under Construction at Martuba

Water Trench under Construction at Martuba



Water Trench under Construction at Kartuba

Ain el Gazala. Water Supply Point in Dunes, Showing Central Well and Pipeline to Pumps machinery of the Salzgitter * cable drilling type and the claw drill type. Details will be found in Section IV.

1 water distilling company, 150 strong, with six mobile installations for distilling drinking water from sea water. Details will be found in Section IV.

2 water filter companies, each 150 strong, with regular army filter equipment, large and small types. Details will be found in Section IV.

1 water supply point operating company, 200 strong, to operate machinery at completed water supply points and administer the distribution of water supplies.

3 water supply transportation columns, each with a capacity of sixty tons, for the transportation of water to the troops.

1 geological detachment.

Each division had:

1 light water supply construction company, 150 strong, with light drilling equipment.

1 water filter company, 150 strong, with regular army filter equipment, large and small types. Details will be found in Section IV.

When the African Panzer Army was formed in the spring of 1942, the water supply units were taken from the Africa Corps and from the divisions and assigned to the army headquarters, where they were controlled by the Water Supply Branch of the Chief Supply and Administration Officer of the army. The Chief of the Water Supply Branch was an engineering officer **

* Trade name

** Officers with technical college degrees. Not to be confused with officers of the engineer arm.

with the rank of lieutenant colonel. The branch handled all planning and the employment of all water supply units. Whenever necessary, the chief of the Water Supply Branch assigned water supply units to corps headquarters, but never to any division. The assignments were usually only for a specified period and for specific purposes.

The heavy water supply construction company had deep well drilling equipment. However, for the reasons previously stated, this equipment was never needed and the company was therefore employed on missions similar to those of the light water supply construction companies. The light companies were intended for employment in the construction of pit type wells and water trenches and were therefore equipped with manual tools, such as pickaxes, spades, and shovels.

The water supply point operating company was employed by platoons or squads at operating the water supply points in the communications zone and at issuing water to the supply vehicles of the divisions.

The distilling company had six mobile water distilling plants with which drinking water could be distilled from sea water. The company was employed only in exceptional cases since the fuel consumed in this method of obtaining water was so great that it could be resorted to only in an extreme emergency, as was the case during the 1942 advance to Egypt, when all wells were found to have been polluted and the constantly growing enormous distances made the forward transportation of water impossible.

For units below division level, water supplies were forwarded together with other supplies by motor vehicles as part of the normal supply transportation service. Each unit was assigned a water supply point developed and operated by the army, from where it received its water rations according to its current strength. The greater part of the water was transported in twenty-liter Wehrmacht cans. Tanker trucks and transportable or permanent large water tanks, as normally used by the British army, were available in small numbers which had been captured and were highly prized by the troops. Unit medical officers were responsible for the supervision of proper sanitary measures.

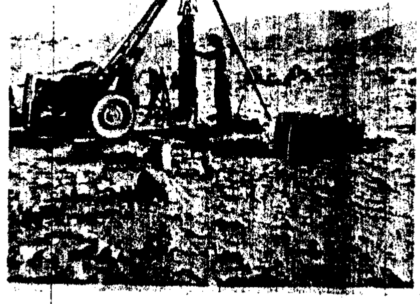
The organization of the water supply service in Africa was simple but proved very satisfactory. The twenty-liter water cans in use in the Wehrmacht proved very useful. They made the proper and rapid distribution of water possible and were easier to keep clean than the large tanks, which caused the British many difficulties so far as cleanliness was concerned.

IV. WATER FINDING, DRILLING, PURIFYING AND DISTRIBUTING EQUIPMENT

To find water was the mission of the geological detachment, which was equipped with the normal instruments and maps for this purpose. In addition, the detachment had a direct current geo-electrical surveying instrument which had been developed by the Army Ordinance Office. Unfortunately, this instrument was lost during operations in 1941 and could not be replaced. An instrument of this type should prove extremely useful in opening up water in the arid zones although it admittedly reacts far more strongly to salt water than to potable water, since the latter does not induct electric current as well.

The deep well drilling machines available were of the Salzgitter, cable drilling type, which had been developed from the tried and tested models produced by Anton Raky A.G., Salzgitter. As previously stated, they were not used during the campaign, so that nothing can be said as to their suitability. If it had become necessary to use them, the great amount of water required for drilling would doubtless have proved a serious drawback, since it would have had to be transported to the drilling site.

This difficulty would have been avoided if the Benoto claw type drilling machine, which was also available, had been used. This drill was equipped with a heavy hammer, to the head of which movable claws of specially hardened steel were attached (photos 26-29, pages [illegible]). However, this drill could only be used in looser types of ground, such as sand, clayey soil, rubble and so forth. In operation, the hammer was allowed to drop to the ground, where the claws were forced into the soil and automatically closed. In lifting the hammer, the soil was held and raised with the claws until released and deposited on the surface. The machine was named after its inventor, a Frenchman, and was constructed in two models, a light and a heavy model, under licence in Germany. With the heavy model, which was intended particularly for work in clayey or gravelly soils, it was possible to drill fifteen to twenty meters daily. However, it was not possible to continue drilling after the water level had been reached, since the water had too great a retarding effect on the velocity of the falling hammer. The lighter model was used chiefly for drilling test holes, and could drill as much as ten meters daily. The diameter of the well thus sunk was seventy centimeters. The principle



Light Benoto Drilling Machine in Operation at Sollum

Light Benoto Drilling Machine in Operation, Showing Center Before Drop

Light Benoto Drilling Machine in Operation, Hammer Dropping

Light Benoto Drilling Machine in Operation. Hammer at End of Drop

of operation of these machine were good but the construction was faulty, so that drilling operation were frequently held up. The main drawback was that the wire ropes were not strong enough and wore out too soon on the guide pulleys. Furthermore, the claws were not strong enough for the strain to which they were subjected. If these deficiencies can be removed, this type of drill will prove a very useful help in desert warfare.

Distilling plants mounted on motor trucks were used to distil potable water from sea water. They used gas as fuel, the consumption being one liter of gas to produce ten liters of potable water. On account of this high rate of fuel consumption, they could only be used in emergencies but then performed satisfactorily, as was the case particularly during the advance to El Alamein. During this operation, the British had rendered all wells useless by pouring bone oil into them, so that it would have been impossible to maintain water supplies for the troops without the water distilling plants.

The standard types of army water filters were available for purifying water. These filters had been used previously in other theaters of operations. They were furnished in two sizes, a large and a small filter, in which the water was forced through a filter cloth impregnated with a decontaminating agent. These filters were used successfully when water supplies were taken from rain water lakes.

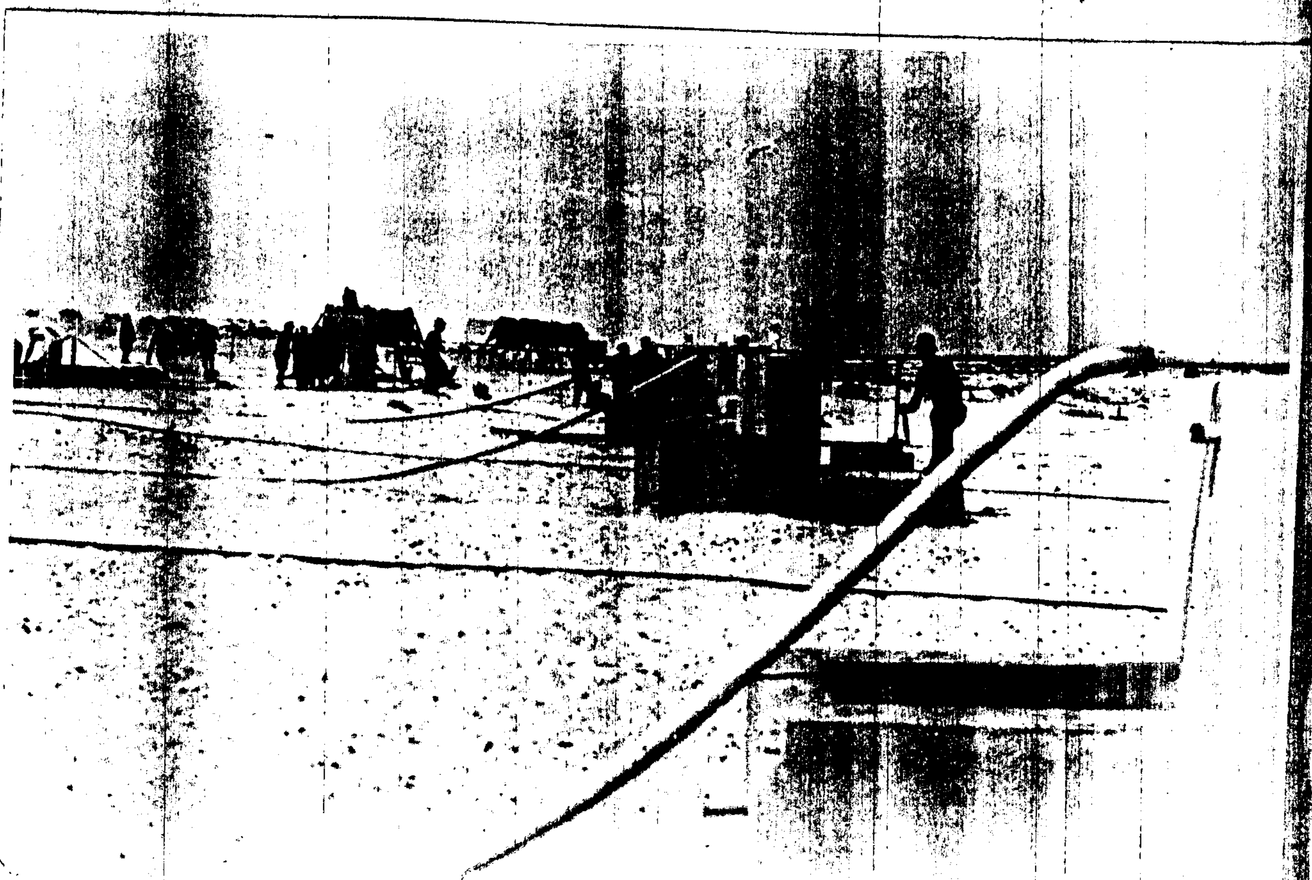
Water taken from wells and other sources was not filtered. In arid areas, water is not likely to be polluted by organic substances, and since all troops had strict orders not to use any water before boiling it, filtering was unnecessary. No steps were necessary to compel the troops to observe the order not to drink unboiled water, since the stagnant water that was found seemed hardly palatable. The German forces had no decontaminating tablets similar to those used by the British.

As previously stated, the standard twenty-liter cans in use in the Wehrmacht were used in the distribution of water. They were marked with a white cross to distinguish them from gas cans.

V. EFFECTS OF LIMITED WATER SUPPLIES ON MILITARY OPERATIONS

How seriously water supply problems affect all combat operations in the desert is best revealed by the following calculation: The daily solid food ration for a soldier weighs roughly one kilogram; the minimum amount of water required per man is four liters, the weight of which is four kilograms. Thus, if there is no possibility of obtaining local water supplies, so that all water has to be carried forward, the transportation space requirements are multiplied by five. The situation will be found to be even more unfavorable if consideration is given to the fact that the pay load of vehicles is far lower in desert terrain than in more developed areas, since the vehicles not only have to carry more fuel for the longer distances between gas supply points but also require more fuel per mile travelled on acount of the poor roads. The ratio of supply troops to combat troops rapidly becomes so adverse the farther the troops move from their supply base that the conduct of an entire operation is endangered.

It follows from what has just been said that ground operations will



Water Supply Point at El Cherruba in the Southern Foothills of the Cyrenaica Mountain Range, Showing (in Photo 31) the Hand-Pump in Use

Water Supply Point at El Charruba in the Southern Foothills of the Cyrenaica Mountain Range, Showing (in Photo 31) the Hand-Pump in Use always be avoided in desert areas if the strategic objective can be reached in some other way. If ground operations cannot be avoided, the number of troops employed must be kept so small that they can obtain their water supplies from water supply points situated within the zone of operations. The quality of the personnel and materiel employed will have to make up for the quantities that cannot be employed. Only thoroughly trained elite troops and the very best equipment should be employed.

In any case it can be stated that, with modern means of warfare, a broad expanse of desert is a more effective barrier against attack than an ocean. This statement is borne out by the course of events during the African campaign. Both opposing armies clung desperately to the coastal zone with its ample supplies of water and only entered the real desert as far as water could be transported without difficulty, a distance of one hundred kilometers at the utmost. Enveloping operations were only carried out if the distance from the coast was relatively short. The enveloping operation farthest from the coast was carried out by Rommel on 26 June 1942 and carried the German forces one hundred kilometers into the real desert. In that operation, Rommel bypassed the British Gazala position south of Bir Hacheim with all his mobile forces, namely, five motorized and armored divisions, including the Italian units. However, the British succeeded in cutting his supply line within a very short while and Rommel was forced to open up a direct supply channel through the British positions. This he did by facing his forces about to attack the British and taking Got el Ualeb, the main point in the

British defence system.

However, neither side took advantage of the many possibilities to outflank the enemy in a wide sweeping movement. Thus, the British did not attack the Cyrenaica region from their positions at the Kufra oases, 1 000 kilometers south of the coast, nor did they bypass the German El Alamein position by driving through the Siwa and Giarabub oases south of the impassable Qattara Depression. Particularly during the 1941-42 winter operation, Rommel feared that the British would attack the Agedabia narrows in a movement from Giarabub. This attack would have severed the communications of the Axis forces completely and irreparably, but it failed to materialise. Finally, the British and Free French forces did not advance from Fort Lamy and Lake Chad to Tripolitania.

Although it must be admitted that serious terrain difficulties would have had to be surmounted in any of the operations just mentioned, the lack of water in the regions involved was by far the greatest deterrent.

That the relatively weak German forces employed were able for so long a time to hold a tiny bridgehead on the continent of Africa, which in its entirety was in the hands of the Allies, was due in no small measure to the broad desert zone of the Sahara, which had the effect of an obstacle zone.

The only forces employed by the British in widely sweeping movements to bypass the German positions were small reconnaissance and sabotage detachments, which consisted of officers and men with desert experience. The most famous and best unit of this type was the Long Range Desert Group under Lieutenant Colonel Stirling. The German forces restricted themselves to the employment of a special unit, the Schulze-Kampfhenkel Exploration Detachment, in one single reconnaissance operation in the Murzuck region. As far as the author is informed, this unit encountered no difficulties in respect to water supplies; this was due to the fact that only a small body of hand-picked and excellently equipped men was involved.

In the light of modern military experience it would seem that the employment of airborne units is the best method to surmount the difficulties of wide desert tracts, provided the side employing them has complete mastery of the air. Once a bridgehead with an ample local supply of water has been established in the enemy terrain, it will be possible to move forward all other supplies by surface transportation without serious difficulty.

It was only in a few isolated cases that the limited water supplies had a decisive effect on actual combat operations. A case in point was that of the strong points in the Italo-German Sollum Line. In January 1942, the Axis forces had withdrawn from the Tobruk region to the Gulf of Sirte. Roughly 600 kilometers east of the new German line, the Sollum strong points continued to hold out, tying down sizable enemy forces. Supplies for the strong points were forwarded by air with great difficulty. In mid-January, British planes succeeded in destroying the wells from which the garrisons drew their water supplies and as a result the courageous garrisons had to surrender.

On the other hand, the story published in the Reader's Digest that in July the German forces had to halt their advance on Cairo because of a lack of water caused by the fact that the British had pumped sea water into the water system of El Alamein is a fable. The sole reason why the German advance was halted was the lack of striking power and had nothing whatever to do with water or other supply difficulties. As previously mentioned in this study, the lack of water was remedied during this operation by the employment of the water distilling company, which distilled potable water from sea water.

VI. AIR TRANSPORTATION OF SUPPLIES

The air transportation of supplies for ground units in action in the African campaign was the last possibility to maintain the flow of supplies from Europe to Africa when all other supply channels were closed. Thus, during the October fighting around El Alamein, motor fuel and some types of ammunition which were in short supply were transported by plane directly from Europe to the front because the British, who had air superiority at that time, were sinking all tankers. However, it was found that the German transport planes themselves required at least fifty percent of the fuel they could carry. Air transportation thus proved an extremely uneconomical undertaking which could be employed only in cases of dire emergency.

When Rommel was to launch his enveloping attack against the British El Alamein position at the end of August, he stated that for this purpose he would require a daily supply of at least 500 cubic meters of motor fuel, the greater part of which naturally would have to be moved forward by air. Kesselring undertook to meet this demand but in actual fact only a fraction of the essential minimum arrived, so that the attack had to be halted. The transportation of such quantities by air was found to be impossible, chiefly because the enemy had complete mastery of the air.

During the final battles around Tunis, the brunt of the supply service was borne by the German air force, since hardly a single ship could cross the Mediterranean safely. As the enemy had air superiority, enormous losses were suffered, the scale of which was such that they could not be borne by the German air force for long. Thus, in the first few days of May, all twelve available large transport planes of the Gigant model were shot down and destroyed, together with their cargoes.

The position would probably be fer more favorable if at least air parity existed and if large, modern transportation planes of the type presently used by the USA in the Pacific were available. However, it will no doubt always depend on local circumstances whether air or ground transportation is preferable. If the terrain and the enemy situation permit, ground transportation will be preferred, since it is safer and cheaper, even though considerably slower. Nevertheless, air transportation units should always be held available during desert operations so that they can be employed immediately in cases of emergency or if the tactical situation requires their employment.

VII. SPECIAL TYPES OF VEHICLES FOR TRANSPORTATION

During the African campaign the German and Italian forces had no specialized types of transport vehicles. There was also no need for special types of vehicles because all heavy transportation could use the asphalt-paved coastal road. With the exception of a few impassable tracts, even the desert can be traversed on trails by normal types of trucks, although attrition, particularly in springs and shock absorbers, is higher than under normal road conditions.

Wear and tear was particularly heavy in the stony desert of El Alamein and if the coastal road had not been available, the supply services would have caused considerable difficulties. This was particularly noticeable in 1941, when German forces were besieging Tobruk. At that time the region traversed by the coastal road was held by the British and had to be bypassed by all German traffic. As a result, it proved extremely difficult to supply the forces employed east of Tobruk, since all vehicles had to travel very slowly through the extremely difficult terrain and quite a number of them broke down. If the entire route from the port of Tripoli to the front at Tobruk had consisted of trails of the type used here, it would have been necessary to treble transportation space and the motor fuel allowances would have had to be nine time as much as they were. Therefore, the development of a special type of sturdy transportation vehicle is extremely important in preparing for desert warfare.

VIII. SPEEDY CONSTRUCTION OF ROADS FOR SURFACE TRANSPORTATION

The system of firming road surfaces rapidly by means of chemical agents, recently developed in America, was unknown at the time of the African campaign; otherwise it would have been used extensively by the German forces, since nothing can facilitate supply transportation more than good roads. Even if sturdy trucks of a special type are available, the fact remains that if roads are poor they slow down the speed of all traffic. If the speed of traffic can be doubled, transportation space requirements are halved. In desert warfare it is therefore advisable to employ modern road construction machinery in such quantities that at least one unit will be available to each division.

During the African campaign, road construction was restricted to a minimum but nevertheless necessitated the employment of large numbers of troops and took up much time. The troops employed for this purpose were furnished by Italian labor units. The most striking performance in this field was the construction of the road built to bypass Tobruk.

The significance of the rapid construction of supply routes is illustrated by a passage taken from Rommel's memoirs on Africa, which reads as follows:

> The movement of supplies for our troops in the Sollum - Halfaya - Bardia line in the summer of 1941 presented special problems. Since the coastal road was closed by the British in Tobruk, all supply traffic for the troops east of Gambut had to move through the terrain around Tobruk. The old trails which had been marked for use in this terrain were so worn out that they could only be traversed with difficulty. At many points it was found to be utterly insurmountable for small vehicles and trucks could only be driven through by taxing their motors to the utmost. If a column of trucks managed to cover the distance around Tobruk within a day, this was considered an excellent performance, and the distance was only roughly seventy kilometers. I therefore exerted all my influence in urging the top level Italian authorities to build a road bypassing Tobruk.

The road referred to by Rommel, which was called the Axis Road, was constructed in the summer of 1941 by specially qualified Italian construction units in work lasting two and one-half months. It was seventy kilometers long, five meters wide; the surface was ballasted but, in contrast with the coastal road, was not asphalted. In view of the extremely primitive equipment available in northern Africa this performance was remarkable (sketch 5, page 57).

IX. FEATURES REQUIRED IN SPECIAL TYPES OF VEHICLES

One of the most important requirements is the production of an all-terrain truck with a capacity of three to three and one-half tons. It should have a high-ratio gear, four-wheel drive and a differential lock. Low pressure balloon tyres should be used; twin tires proved unsatisfactory as small pebbles became wedged between the walls of the two tires.

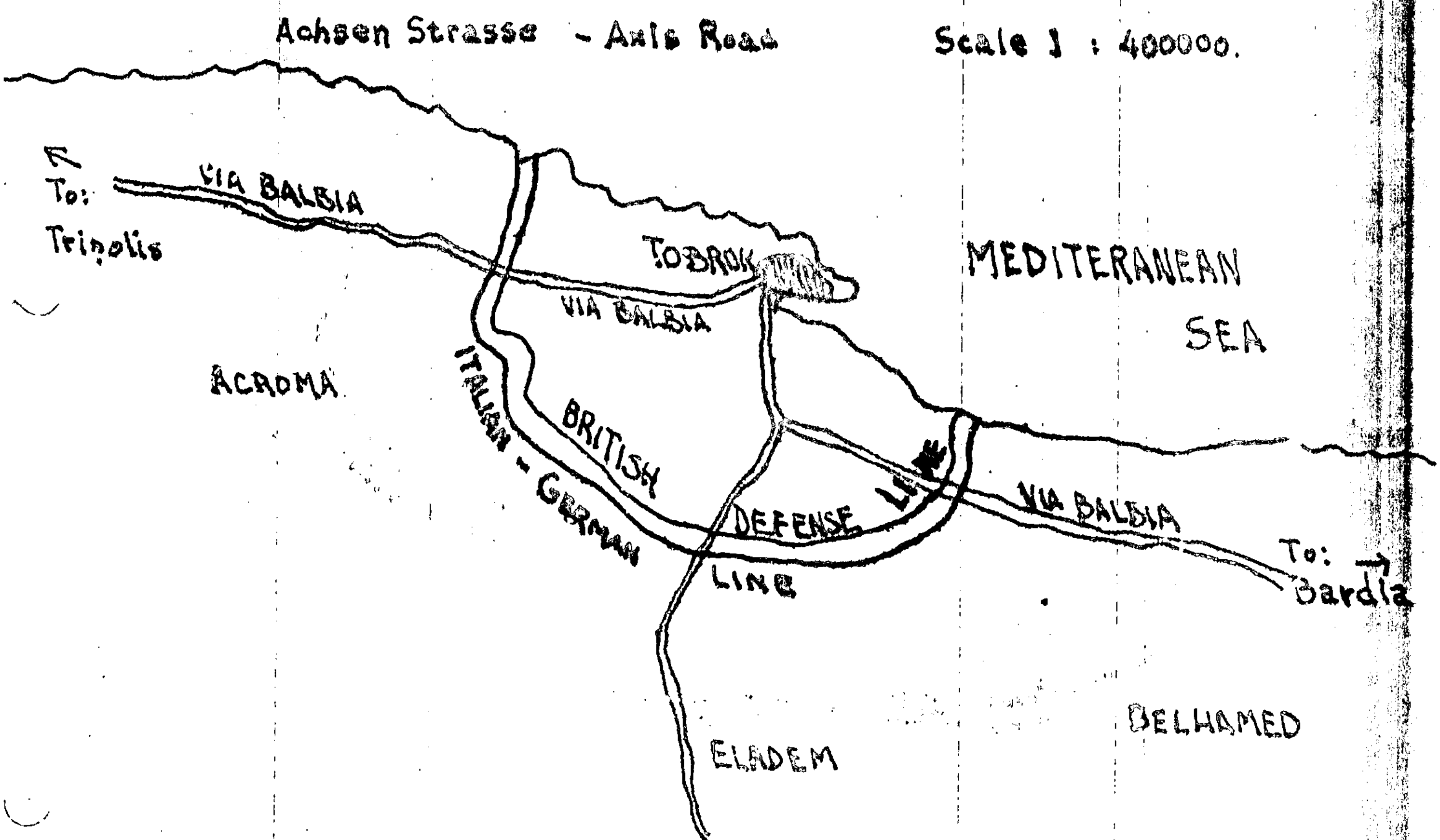
Whether air cooled engines will prove suitable is a moot point. The Steyr factory in Austria had developed an air cooled engine, but trucks with this engine only arrived in the theater shortly before the close of the African campaign, so that they could not be adequately tested. While they were in use, they performed satisfactorily.

Particular attention must be paid to springs and shock absorbers. The helical springs used in the German Model 15 and 17 all-terrain cars were not satisfactory. The springs broke easily and replacements were not readily obtainable. Laminated leaf springs gave better service but should be stronger and each wheel should have independent suspension. This latter requirement was met by the British Ford, whereas the German Ford had transverse suspension of the front wheels. For this reason the British model proved superior to the German, in which the front spring was inadequate.

MS # P-129

Anlage 10

Sketch 5



In the desert all vehicles should carry shovels and planks or brush mats for use if they bog down in the sand. Conditions in the Russian theater of operations made similar equipment necessary.

It is also advisable to furnish each car and some of the trucks with compasses, which should be so placed that they are at all times visible to the driver. Each compass must have a magnet attached to compensate for deviations. At the time under review, suitable compasses were manufactured by the Askania Werke, Berlin-Friedenau.

Passenger cars should be as light as possible. The Volkswagen * met this requirement and performed satisfactorily. In cars, air cooled engines are preferable. All cars must be able to carry a sufficient supply of fuel and water.

X. OPERATIONAL RESTRICTIONS CAUSED BY FAILURE OF SUPPLIES TO KEEP PACE WITH COMBAT UNITS

During the African campaign no single case occurred in which the supply services failed to keep pace with the combat units owing to technical difficulties. The fact must be taken into consideration here that all advances and all combat action took place in proximity to the asphalted coastal road, so that a secure supply route was available. It is true that difficult trails had to be used in distributing supplies to the individual units, but it was nevertheless possible to move forward all supplies to the combat troops in good time because the German tanks could not travel faster in the desert than the supply vehicles. Furthermore, combat action caused delays, which made it possible for the supply

* The German equivalent of the jeep.

columns to catch up with the advancing units.

If a unit is well integrated, operations need not be slowed down by the low speed of supply transportation, particularly if the unit has facilities to build good roads speedily and has special types of transport vehicles. More serious difficulties are only likely to be encountered if it becomes necessary to transport all water required, a subject which had been dealt with in Section V.

/s/ Fritz Bayerlein

CHAPTER 8

THE ORGANIZATION OF THE WATER SUPPLY SERVICES IN THE BRITISH ARMY AND GEOLOGICAL DATA

by

Dr. Sigismund Kienow

I. COPY OF A REPORT PREPARED ON 2 JANUARY 1942 ON THE BRITISH ORGANIZATION

1. The Organization in General. Particular attention is paid to water supply problems in the British Army in Africa. The organization is firm and extends down to the lowest level units, each of which has its own water supply officer.

The purposes of the organization are as follows:

a. Distribution of water to units.

b. The supply of adequate and suitable cans and other containers to all units.

c. The maintenance of specified stores of water supplies at company and battalion levels.

d. Health control.

Apparently the finding of water and the selection of supply points are the responsibility of Eighth Army Headquarters and not of the brigade*. Only major wells with an adequate flow of water are used; only one report, dated 16 October, mentions that units occasionally also use

* Fifth South African Brigade.

small, shallow wells to obtain water supplies. Usually, water is issued against a certificate signed by an officer and showing the man power of the unit concerned.

In addition to the personnel handling the issuing of water supplies, water police personnel are stationed at the water supply points for control purposes as well as night guards to prevent sabotage or the unauthorized drawing of water.

"Water" discipline is rigidly enforced. In cases where units have drawn more than their authorized water rations, the persons responsible have been called to account.

While the brigade was operating in the western desert, the water rations were forwarded to the individual units in cans by the [illegible] teams. Empty water cans were exchanged for full cans at the water supply points. In addition, each unit had a water platoon responsible for the transportation of the reserve supply of water (subsection 2, p. [illegible]).

2. Water Rations. The normal water ration is 1.5 gallons per capita per day. No mention is to be found of any difference being made between water for drinking purposes and water for other purposes. The only type of water supply specifically mentioned is the water supplied for engine cooling, which is included in the over-all allowance.

A ration of one gallon per day was considered inadequate by the troops in summer. On 24 August 1941, a unit employed at entrenchment work submitted a request that the ration be increased to 1.5 gallons, since one gallon was required for drinking purposes alone. The fact that the authorized ration was exceeded occasionally by certain units (in some cases by as much as roughly twenty-two gallons) indicates that the authorized ration was inadequate.

An increased ration of 1.5 gallons was allowed for units stationed in the Daba region. Furthermore, troops stationed in this area received an additional water allowance for special purposes, for instance, for use in hospitals, canteens, compressor stations.

The water situation was far more strained farther west, in the Matruk and Sidi Barani regions and in the western desert. Troops stationed there received only one gallon per capita per day, without any special allowance for other purposes. However, unit commanders in these areas were authorized to regulate the use of water issued to their units.

3. Water Reserves. Each unit was required at all times to maintain a transportable reserve supply of water, for which purpose it was furnished the necessary containers and vehicles. Information varies as to the number of days for which a reserve was to be maintained and the quantity of the daily ration. Apparently this was decided by the mission for which the unit was intended.

Conflicting orders were issued occasionally and led to difficulties and controversies at lower levels. This was particularly the case in June, at which time the organized water supply had just been introduced. Most frequent mention is made of a reserve of one-half gallon per capita per day for a period of fourteen days, plus two gallons per vehicle per week. Consequently, a unit 200 strong and with 50 vehicles would have been required to maintain a reserve supply of 1400 gallons of water for drinking purposes plus 200 gallons for engine cooling. While the brigade was operating in the western desert, the ration for engine cooling was increased to two gallons per three days.

Other orders mention a daily ration of one to two gallons per capita and a period varying between seven and fourteen days for which a reserve was to be maintained. Usually, it was impossible to carry out these orders owing to the lack of sufficient containers and vehicles.

A further order was issued on 26 June 1941 according to which an additional stationary reserve supply of water was to be maintained in Fort Matruh. The quantity to be maintained for a battalion at normal strength was 3940 gallons. Containers were issued for this purpose but remained the property of Fort Matruh.

While the brigade was operating in the western desert a new regulation came into force, according to which each vehicle was permanently to carry three gallons of water for each person normally on it. This water was to be held as an emergency three-day ration and was only to be used by order of an officer. For the engines, a three day reserve of two to three gallons per vehicle was carried by the water platoon of each unit. Current supplies were brought forward by the 2 supply trucks in cans (subsection 1, page 60).

4. Water Containers. The British army has tank trucks, cans and other water containers of widely varying capacities. The types most commonly in use are the 600 and 400 gallon trucks, the 100 gallon trailers, 120 and 100 gallon tanks, 44 gallon barrels and 12½, 4 and 2 gallon cans. The most usual non-transportable containers are those

with a 400 and 200 gallon capacity.

Initially, sheet iron containers and cans were used. Owing to the danger of rust, these were exchanged later for galvanized metal tanks and cans. It appears that this exchange had been almost completed by November since a report on a medical inspection complains of only a few sheet iron containers still in use.

The total water storage capacity of the brigade consisted of:

5	tank trucks	with a capacity of 600 gallons each
33	tank trucks	with a capacity of 100 gallons each
4	tanks	with a capacity of 100 gallons each
270	cans	with a capacity of 12½ gallons each
123	cans	with a capacity of 4 gallons each
832	cans	with a capacity of 3 gallons each.

5. Health Control. The entire water supply service was under the constant supervision of health officers. Water was chlorinated at the supply points. In cases where this was not done, the unit drawing water supplies was obligated to chlorinate all water it received.

All water containers in use were inspected by health officers at regular intervals, and containers found to be rusty were exchanged against galvanized containers.

All British troops had strict orders not to use captured water supplies before the water had been inspected. Apparently, provision had been made for these inspections to be carried out without loss of time. All units were also issued chlorine water decontamination powder, flavoring tablets to compensate for the unpalatable chlorine taste, ammonia-chlorine tablets and appropriate instruments.

6. Water Supply Points in Western Egypt. The following water supply points are mentioned in orders of the 5th South African Brigade:

a. Wells. Bug-Bug Well with a daily capacity of 15400 - 19800 gallons. The salt content of the water increases if pumping is continued without interruption for a long time. The reservoir has a capacity of 19800 gallons.

Bir Migeit Well with daily capacity of 19800 gallons; irregular flow.

Wells at Murbeita, Bagush, 41 kilometer point, Sidi Haneish, Gerawla, Fuka, Daba, Sanyet Chabir.

b. Cisterns and Reservoirs. Ain Misheifa (reservoirs are filled with rail-borne water).

Sofafi-East. Reservoir with a capacity of 24000 gallons.

Landymower. Reservoir with a capacity of 49800 gallons.

c. Water Pipelines. The western pipeline extends from Alexandria to a point near Matruh. In an Eighth Army order dated [illegible] October, the further extension of this pipeline is described as being of prime importance and severe economy in the use of water is demanded. Water supply points along this pipeline are situated at:

Field Service Depot 29. (Capacity 39600 gallons daily; reservoirs available after 17 November with a capacity of 39600 gallons against the former capacity of 19800 gallons).

Oxford Water Point. (Daily capacity 9900 gallons; reservoir capacity 39600 gallons).

Bir Weir. (Daily capacity 5000 gallons; reservoir capacity 52400 gallons).

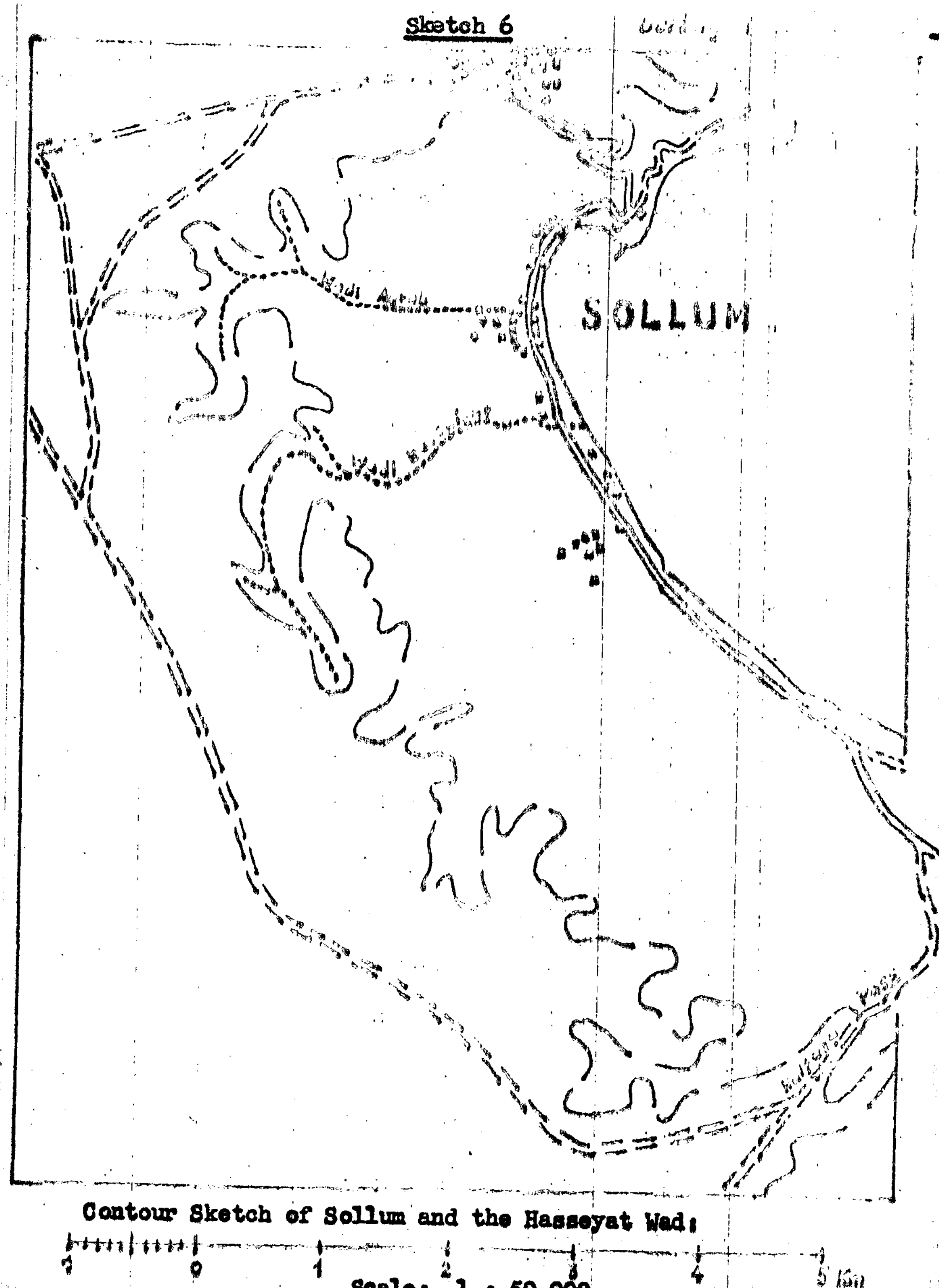
/s/ Dr. Kienow
Kriegsverwaltungsrat

The above report was compiled on 2 January 1942 on the basis of documents captured from the 5th South African Brigade.

II. REPORT BY THE MILITARY GEOLOGICAL DETACHMENT OF THE GERMAN AFRICA CORPS ON WATER EXPLORATION IN THE HASSEYAT WADI, SOUTHWEST OF LOWER SOLLUM, IN SEPTEMBER-OCTOBER 1941

1. Physical Features. (Sketch 6, page 67). The source of the Hasseyat wadi is in the immediate vicinity of the steep fall from [illegible] el Aquaba mountain to the Sollum lowlands, roughly five kilometers northwest of the Halfaya Pass. For the first two kilometers its course runs parallel with the precipice in a northnorthwesterly direction. Then it bends sharply eastnortheastwards and about one kilometer further on enters the Plain of Sollum at an altitude of about twenty-five meters above sea level. It continues its course in an eastnortheasterly direction and flows into the Mediterranean at a point 1.5 kilometer south of lower Sollum. In its upper reaches, the bed of the river is deeply cut into the miocene limestone formation and has steep banks. In its lower reaches the river bed is far shallower in the alluvial deposits which cover the floor of the Plain of Sollum and in many places the banks are precipitous. At two points the river has cut its way through the solid chalk-like rock, which is probably of diluvial origin, beneath

Sketch 6



Contour Sketch of Sollum and the Hasseyat Wadi

Scale: 1 : 50 000

Maßstab 1:50 000

	Trauf der Hochfläche	Contour of High Plateau
	Strasse	Road
	Piste	Trail
	Wadi	Dry River Bed (Wadi)

the alluvial deposits. In the higher parts of the lower reaches, the bed of the river is eight to ten meters deep, in the middle third four to five meters. In the final third of its lower reaches, the banks rapidly become much lower and on the seaward side of the Sidi Barrani - Sollum road the river forms a narrow delta which is hardly discernible in the terrain.

Vegetation is sparse along the lower reaches of the river; in the last third of its lower reaches a scattered forest of dwarf fig trees will be found.

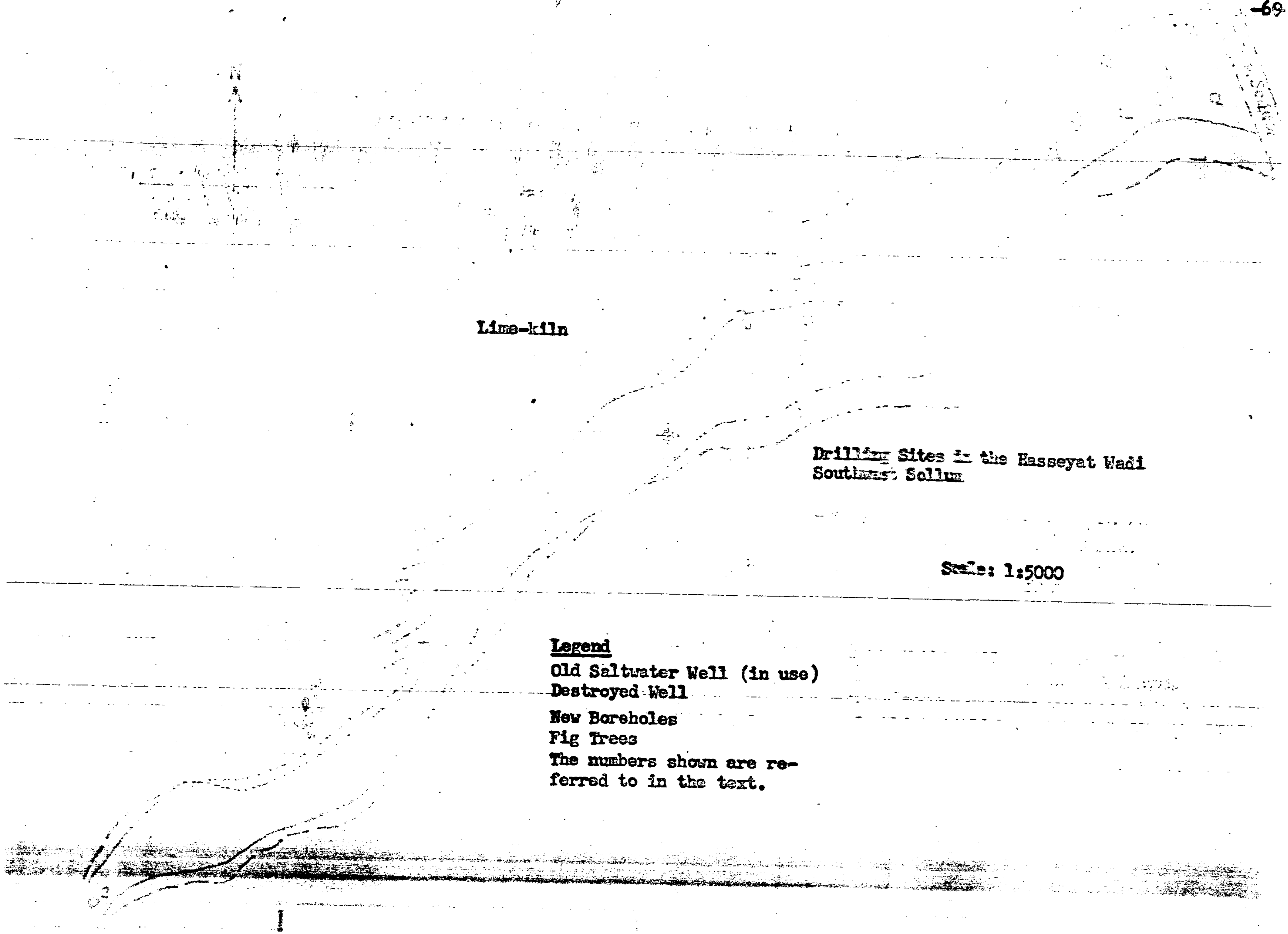
2. <u>Subsoil</u>. The lower strata consists of a chalky marl, probably of diluvial origin. At many points the top layer of this marl, which was reached at a depth of nine meters in borehole 1 and at a depth of eight meters in borehole 6, has become decomposed to form a greenish soapy clay. The site of borehole 3 was close to the northern bank of the wadi in the vicinity of a spot where the water had cut into the chalk-marl strata (sketches 7 and 8, pages 69 and 70).

This bottom strata was covered by alluvial deposits of sandy clay; quartz and limestone sand with an average granulation of five millimeters; quartz-limestone sand and limestone boulders with an average diameter of five centimeters.

These deposits were found in the order given, counting from the bottom, and become coarser towards the top surface. The thickness of the individual layers varied widely. Isolated patches were found in which boulders predominated (sketch 9, page 71).

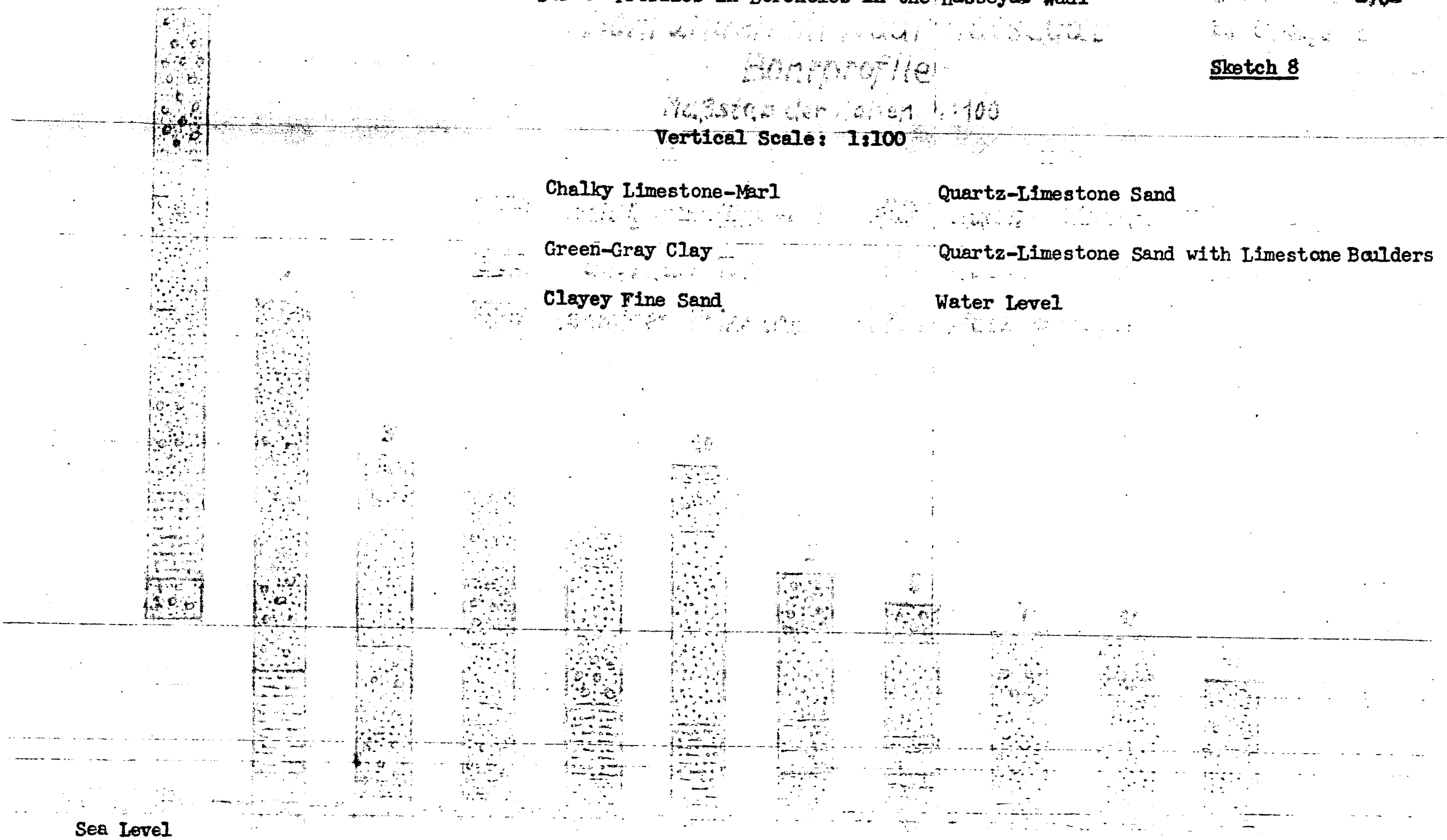
3. <u>Water-Bearing Strata</u>. No water was found in boreholes 1 and 2,

Sketch 7


N
Lime-kiln
Drilling Sites in the Hasseyat Wadi
Southeast Sollum
Scale: 1:5000
Legend
Old Saltwater Well (in use)
Destroyed Well
New Boreholes
Fig Trees
The numbers shown are re-
ferred to in the text.

Strata Profiles in Boreholes in the Hasseyat Wadi

Sketch 8



Longitudinal Profile of Lower Reaches of Hasseyat Wadi

Sketch 9

Longitudinal Scale: 1:2500

Vertical Scale: 1:500

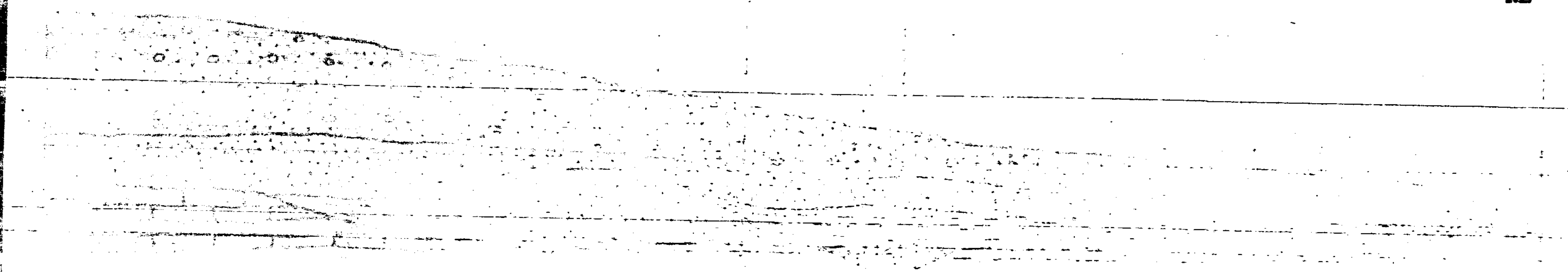
Chalky Limestone Marl

Clayey Fine Sand

Quartz-Limestone Sand

Quartz-Limestone Sand with Limestone Boulders

NE



the sites of which were in the upper reaches of the wadi; this fact serves to show that no water was flowing from the upper reaches at the time of drilling operations. In boreholes 3 - 12 water was found at depths varying between sea level and 30 centimeters below sea level. The subsoil water level was deepest in boreholes 11 and 12, which were drilled in the last lower reaches of the wadi, so that the water-bearing strata obviously slopes gently downwards with the wadi.

A chemical analysis of the water found in borehole 6 showed the following results:

Smell: none	Chlorine: 100 mg per liter
taste: refreshing, pleasant	Nitrates: none
color: none	Nitrites: none
color of a sample taken from a 30-cm profile: light bluish green	Sulphate: traces
Translucence: opalescent (due to clay particles)	Ammoniac (NH_3): none
Reaction: neutral	Hardness: 7 degrees

The water found in the other boreholes was tested only for the presence of chlorine. The results found are given below:

Borehole #	Elevation, above sea level (meters)	Below sea level (meters)	Chlorine content (in milligrams per liter)
1	9.64	--	--
3	6.00	0.08	1100
4	6.11	0.00	900
6	6.14	0.07	100
7	3.23	0.15	330
8	3.91	0.22	340

Borehole #	Elevation, above sea level (meters)	Below sea level (meters)	Chlorine content (in milligrams per liter)
9	4.21	0.10	1520
10	6.40	0.16	1730
11	2.61	0.34	1500
12	3.21	0.39	1380

It will be noticed in sketch 10, page 74, that the subsoil water in a narrow zone commencing at the point where a tributary joins the wadi and extending eastnortheast has a particularly low salt content. It was therefore to be assumed that fresh water flowed from this tributary. Borehole 13 was drilled to test this assumption, but no water was found.

Since no influx is taking place at present from the higher reaches of the wadi and since the subsoil water level has only a very slight downward slope, the fresh water present must be from the last rains and probably is floating in a very thin layer above the salt water.

In most cases, the subsoil water is to be found in alluvial deposits. Only in one case, in borehole 8, was it found in a limestone-marl formation. It is to be assumed that the flow of water continues in this formation so that further holes must be drilled to ascertain the extent and the quality of the water present in the limestone-marl formation. The light model Benoto drilling machines available to the military geological detachment are not adequate for this purpose.

4. Suggestions for the Use of Wells. It is to be assumed that only a thin layer of fresh water is available. Therefore, rapid pumping and pumping from too low levels must be avoided. Water must be drawn from as wide a surface as possible to permit the influx of fresh water from the

sides.

In the sinking of wells it is therefore suggested

a. that the diameter be as great as possible;

b. that the bottom of the well be sealed off to prevent the rise of salt water from lower levels;

c. if timber or metal is used for the well lining, apertures must be provided for the influx of water from the sides. If the wells are walled with stone, the walls must be unmortared;

d. the top of the well must be covered properly to prevent increased salt content through evaporation;

e. to prevent too rapid drawing of water, power pumps should not be used.

5. <u>Sample Profiles.</u>

Borehole #	Levels (in meters)	Formations found
1	surface to depth of 50 centimeters	quartz-sandstone sand with sandstone boulders and rocks
	0.50 - 7	as above; moist; traces of clay
	7 - 7.60	sandy, greyish-yellow clay
	7.60 - 9	greenish-gray soapy clay
	9 - 10.20	whitish-grey brittle sandstone

Borehole #	Levels (in meters)	Formations found (cont.)
2	surface to depth of 2.80 meters	limestone-quartz sand with limestone boulders
	2.80 - 6.80	layers of quartz sand and limestone boulders
	6.80 - 7.20	damp quartz sand
	7.20 - 9	quartz sand with limestone boulders
	9 - 10.40	damp clayey quartz sand
	10.40 - 11.50	limestone boulders with limestone-quartz sand
3	surface to a depth of 1.10 meters	quartz-limestone sand with limestone boulders
	1.10 - 6.40	layers of quartz-limestone sand and limestone boulders
	6.40 - 6.80	fine sand, wet and clayey
	6.80	water
4	surface to depth of 4.10 meters	layers of quartz-limestone sand and limestone boulders
	4.10 - 4.40	clayey fine sand
	4.40 - 5.40	quartz-limestone sand with limestone boulders
	5.40 - 6.30	fine sand, clayey
	6.11	water
5	surface to depth of 3 meters	noticeably dry limestone-quartz sand with large limestone boulders

Borehole #	Levels (in meters)	Formations found (cont.)
6	surface to depth of 1.20 meters	coarse quartz-limestone sand
	1.20 - 3.20	quartz-limestone sand with limestone boulders; moist in parts
	3.20 - 4.00	fine sand, clayey
	4.00 - 4.60	sandy clay
	4.60 - 5.30	quartz-limestone sand with few limestone boulders
	5.21	water
7	surface to depth of 1.60	limestone-quartz sand with limestone boulders
	1.60 - 3.10	quartz-limestone sand with limestone boulders and clayey fine sand in layers
	3.10 - 3.70	sandy clay
	3.50	water
8	surface to depth of 70 centimeters	quartz-limestone sand with few limestone boulders
	0.70 - 2.50	layers of quartz-limestone sand and limestone boulders
	2.50 - 3.20	clayey fine sand with few boulders
	3.20 - 4.50	whitish-gray brittle limestone
	4.13	water

Borehole #	Levels (in meters)	Formations found (cont.)
9	surface to depth of 1.20 meters	quartz-limestone sand with numerous boulders
	1.20 - 2.80	quartz-limestone sand
	2.80 - 3.80	fine sand clayey
	3.80 - 4.70	quartz-limestone sand with limestone boulders
	4.01	water
10	surface to depth of 1.10 meters	quartz-limestone sand with limestone boulders
	1.10 - 4.60	quartz-limestone sand
	4.60 - 6.70	clayey fine sand
	3.85	water
11	surface to depth of 1.20 meters	quartz-limestone sand with limestone boulders
	1.20 - 2.20	quartz-limestone sand
	2.20 - 3.10	clayey fine sand
	2.95	water
12	surface to depth of 1.20 meters	quartz-limestone sand with limestone boulders
	1.20 - 3.40	quartz-limestone sand
	3.40 - 3.80	clayey fine sand with dark spots
	3.70	water

Borehole #	Levels (in meters)	Formations found (cont.)
13	surface to depth of 40 centimeters	surface limestone
	0.40 - 1.70	quartz-limestone sand with limestone boulders
	1.70 - 3.40	slightly clayey sand
	3.40 - 4.00	limestone-quartz sand
	4.00 - 4.20	brittle surface limestone
	4.20 - 5.00	greenish-white clay
	5.00 - 5.70	yellow, slightly sandy clay
	5.70 - 6.00	grayish-white brittle limestone

Water Supply Map

Prepared by the 12th Military Geological Detachment February 1942

Supplies for large bodies of troops

good

adequate

inadequate

only through use of cisterns

Important water supply points for military purposes

(black-operating red-operable at part capacity or not at all

Capacity over 100 [illegible] meters daily

Capacity less [illegible] cubicmeters daily

Small wells (marked on [illegible] areas where water is scar[illegible]

35 cubicme[illegible]


unit supply points.Capacities
marked on map in cubicmeters per hour.
(100m3-100 cubicmeters per hour)
Steep slopes of Nefusa Mountain
First class roads
Second class roads
Total 600 m
per hour
15 wells
19 wells
wells